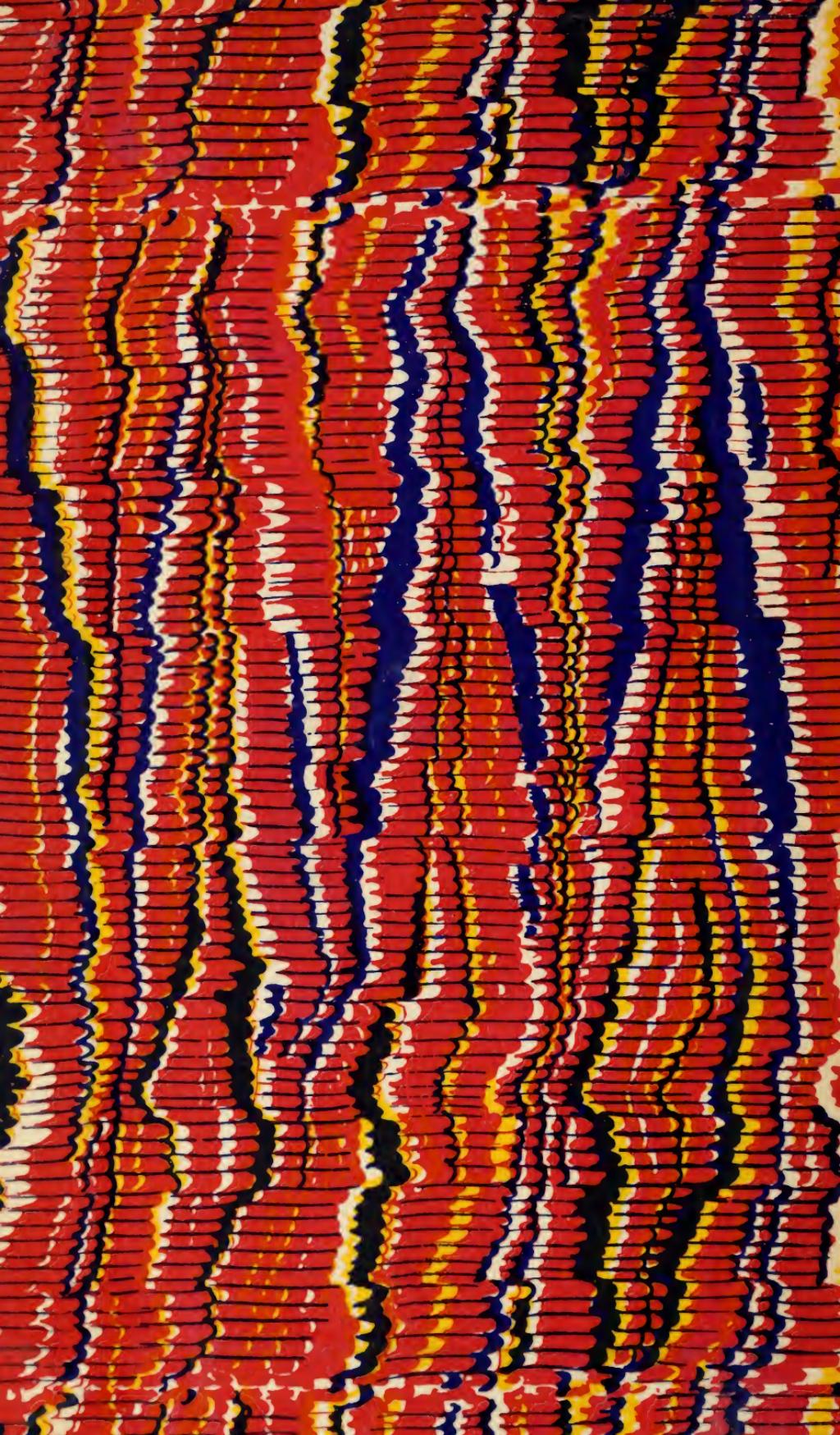


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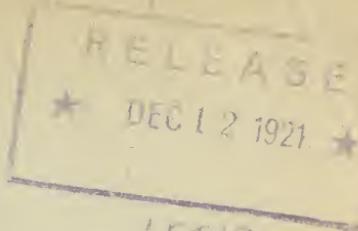




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REPORT OF THE SECRETARY OF AGRICULTURE.

WASHINGTON, D. C., November 15, 1921.

DEAR MR. PRESIDENT:

Before reporting in detail on the work of the Department of Agriculture during the past year, it seems proper to speak of the condition of agriculture in the Nation. The experiences of recent years have shown more clearly than ever before that an efficient agriculture is of vital importance to all the people. During the darkest days of the war success or failure turned on an adequate food supply. Every discovery that reduces the cost of production or increases the efficiency and economy of distribution of farm products benefits all consumers. Any circumstance which depresses agriculture, making it impossible to exchange products of the farm for the products of the factory on a fairly normal basis, makes for closed factories and unemployment in industries. The promotion of our agriculture is, therefore, in the interest of all the people. Conditions which are harmful to the producers and which tend to jeopardize future production must be noted with concern by all of our people and the national energy should be turned toward improving such conditions.

The farmer receives his money wages in the form of payment for his crops and live stock. These wages are not paid regularly every week or every month, except in part in the case of some dairy farmers, but at irregular intervals varying from three months to a year or more, depending upon the nature of the crop. Neither rate of wages nor hours of work is agreed upon in advance. The consuming public pays, but it makes no agreement as to the amount it will pay. The farmer is urged to produce abundantly, but the price paid him for what he produces is set after the amount of his production is known. The buyers drive the shrewdest possible bargain. The more the farmer produces, the less the buyers want to pay. Thus we have large production penalized. Very often—indeed, it is the

general rule—a large crop brings the farmer fewer total dollars than a small crop. And often a large crop sells at less than it costs the farmer on an average to produce it. Such is the condition this year. The energy and the intelligence with which the farmer works, the number of hours he works, the cost he incurs in producing crops—none of these is considered in determining the price.

FARMER PRODUCES ON FAITH.

The farmer, therefore, must work on faith. He must himself carry all the risks of weather, of heat and cold, of flood and drought, of destructive storms, of insect pests, and plant and animal diseases. He must plant enough to make sure that there will be food for all, with the practical certainty that in unusually favorable seasons the result may be a large surplus, and that this surplus, which can not be hidden, probably will cause prices lower than the actual cost of production. He must be willing to accept these low prices with the best grace possible and adjust his living expenses to meet his reduced income. The American farmer always has done this. He is a philosopher, as every man must be who works with nature and is subject to nature's varying moods. And he feels his responsibility to feed the people. If the farmers of America should cease work for a single crop season, millions upon millions of people would suffer for food. They have never ceased work, no matter what the trials and hardships.

In an orderly world the farmers are able one year with another to so adjust their production to the needs of consumption as to enjoy a fairly reasonable share of the national prosperity. During the period of development when farm land is increasing in value, land-owners look upon the enhanced value of their land as accumulated compensation to offset unprofitable crop years. This thought has consoled them under many distressing conditions of crop failures and low prices. As they advance in age and come to the time when they must cease hard work, they have reaped this accumulated value through sale of the farm or through renting on the basis of value. The people of America have until very recent years been fed at a price below the actual cost of producing farm crops, if all of the factors which properly enter into that cost are considered and if the farmer should be allowed a wage no larger than the wage paid for

the cheapest labor. In the case of the investor or speculator, increase in the value of farm land may be unearned increment. In the case of the farmer it is earned increment.

FARMER FEELS RESPONSIBILITY TO PUBLIC.

The farmer must carry also those risks, due to changes in business, both at home and abroad, which influence the demand for farm products; that is, his prices are influenced by the ups and downs of business over which he has no control. In periods of disturbance, which interrupt foreign trade or interfere with home industries and thereby decrease demand for farm crops, the farmer suffers through the reduction of his wage by decreased prices for his crops. When such periods come at a time when the cost of production is unusually high, and especially if one bad year has followed another and thus finds the farmer heavily in debt because of the losses of the previous year, the result is serious and makes trouble for the farmer and everyone else. But the farmer always works. He always produces. He grows food in abundance.

The crops of the year 1920 were produced at the greatest costs ever known. These costs were justified by prices which prevailed at planting time. They were incurred willingly because the farmers had been told over and over again that overseas there was a hungry world waiting to be fed and that there would be a strong demand for all they could produce. The production was large; the farmers worked very hard, and climatic conditions favored good crops. But before the crops were harvested prices had so decreased that at market time the crops sold for far less than the cost of production, considering the country as a whole. Hundreds of thousands produced at heavy financial loss.

DISPROPORTIONATE REDUCTION IN FARMERS' INCOME.

The farmers had taken it for granted that war prices could not continue. They had expected lower prices for their own products. They had not thought that their prices would drop as low as they did, but during the winter they accepted these very low prices with their usual philosophy. They borrowed more money to keep themselves going, and in the face of a continuing decline in prices of almost all of their crops they put out ample acreage in the spring of 1921. At that time prices of farm products were much below

the cost of production and far lower relatively than the prices of other commodities. The farmers' wages had thus been reduced to about the prewar level, but the wages of other people, whether paid direct or through the products of their work, remained very near the war level and from 50 to 100 per cent or more above the prewar level. This was a disturbing condition, but the farmer hoped and had a right to expect that by the time his crops of this year were ready for market other workers and other manufacturers, for the farmer is both, would be willing to accept their share of the burden of economic rebuilding and that the prices of other things, including wages, which have the greatest influence on such prices, would come down to a fairer and more nearly normal relation to the price of farm products. There was no attempt on the part of the farmers to restrict production. In some cases, as with the cotton farmers of the South, there was an effort to readjust acreage by substituting one crop for another. But it can not be said that the farmers of the United States combined to hold up their wages. They showed their good faith and their sense of responsibility in trying times by planting plentifully, reducing their own expenses in every possible way, and working harder and longer hours. As in war time, many women and girls worked in the fields because reduced income made impossible the employment of other help. As the result of large acreage, very hard work, and a favorable season, the crops of 1921, while not as large as in some years, yielded more than we need for our own use, but prices are most unsatisfactory. Accompanying this report is a table showing the acreage and yields in detail.

SURPLUS NEEDED BY HUNGRY PEOPLES.

Had some way been found for the people in need to buy our surplus at prices which would cover the cost of production the American farmer would have been prosperous and the country would have prospered with him. It is a terrible indictment of modern civilization that with such abundance here there are millions of people overseas suffering for the bare necessities and other millions starving to death. And surely we are sadly lacking in our understanding of economic laws or in our adjustment to them when the production of bounteous crops grown by the hard labor of 13,000,000 farmers and farm workers and their families is permitted

to play such a large part in paralyzing our industries and business at home. For that is what has happened. The purchasing power of the principal farm crops of the year 1921 at the present time is lower than ever before known. In times past some of these crops have sold at lower prices per sale unit expressed in dollars and cents, but probably never before have our farmers generally been compelled to exchange their crops per sale unit for such small amounts of the things they need. The purchasing power of our major grain crops is little more than half what it was on an average for the five prewar years of 1910-1914, inclusive.

When we remember that approximately 40 per cent of all our people live in the open country and are dependent upon what grows out of the soil, the baneful effect upon the Nation of reducing the purchasing power of that 40 per cent so far below normal is obvious. The farmer is compelled to practice the most rigid economy, to wear his old clothes, to repair his old machinery, to refrain from purchasing everything he can possibly do without, and to deny himself and his family not alone luxuries but many of the ordinary comforts of life. This in turn has forced the manufacturer to restrict his output to the lessened demand, reducing his own purchases of raw material, and greatly reducing the number of his workmen. Men out of work must live on their savings and are in turn compelled to practice economy by reducing their own buying, and thus still further restrict the farmers' market. And so we find ourselves in a vicious circle which we are having difficulty in breaking through.

EFFECT OF HIGH FREIGHT RATES.

Nor is the foregoing a complete tale of the difficulties and discouragements of the farmer. The cost of getting farm products from the farm to the consumer's table has increased tremendously during the past three years. The freight charge is very nearly doubled, and in some cases more than doubled. When wheat was selling at \$2.50 per bushel, corn at \$1.75, cattle and hogs at \$16 to \$22 per hundred, cotton at 30 cents per pound, the increased freight rate was not a serious matter. It amounted to but few cents relatively and was a small item in the total price. But with wheat at \$1, corn at 48 cents, cattle and hogs at \$7 to \$10 per hundred, cotton at 17 to 20 cents (all these being primary market prices, not farm prices),

the addition of even 10 cents per bushel or per hundred pounds imposes a burden grievous to be borne. When farm prices are ruinously low any addition to the freight charge means added distress. At the present time the cost of getting some farm products to market is greater than the amount the farmer himself receives in net return. And the heaviest freight burden naturally falls on those farmers who live in our great surplus-producing States.

Not only do the very large advances in freight rates impose a heavy burden on the producers of grain and live stock, cotton, and wool, but on the growers of fruits and vegetables as well. Indeed, some of the latter have been compelled to see their products waste in the fields because the prices offered at the consuming markets were not large enough to pay the cost of packing and transportation.

This transportation matter is one of vital importance to agriculture. The country has been developed on the low long haul. Land values, crops, and farming practices in general have been adjusted to this development. Large advances in freight rates, therefore, while bearable in a time of high prices, if continued are bound to involve a remaking of our agricultural map. The simple process of marking up the transportation cost a few cents per hundred pounds has the same effect on a surplus-producing State as picking it up and setting it down 100 to 300 miles farther from market. Agriculture is depressed until the rates are lowered or until population and industry shift to meet this new condition. Any marked change in long-established freight rates, therefore, means a rearrangement of production in many sections and for a time at least favors some areas at the expense of others.

FREIGHT RATES AND FOREIGN COMPETITION.

More than this, inasmuch as our heavy consuming population is massed so largely near the eastern coast and our surplus is produced long distances in the interior, substantial advances in transportation costs have the effect of imposing a differential against our own producers in favor of their competitors in foreign lands, especially to the south of us, who have the benefit of cheap water transportation, and who, in many cases, can lay down their products on our eastern coast more cheaply than our own people can ship their products to the same points by rail.

Rail transportation is essential to our agricultural production. Good rail service is of tremendous importance. Our farmers realize that our railroads can not be maintained and operated efficiently unless permitted to charge rates which will cover all fair operating costs, maintain their roadbeds and equipment, and pay a fair rate on the money invested. No one has a greater interest than the farmer in efficient transportation. At the same time the economic aspects of material changes in railroad rates must be considered more carefully than in the past. If these changes are made without due consideration of their effect on agricultural production, inevitably they will create profound disturbance and impose great injustice.

With the increased charge for transportation have come increased handling charges all along the line from the farm to the market. Including freight, it now costs the grain and live-stock producer just about twice as much to get his products to the primary market and sell them there as it cost him before the war. At the same time the prices paid at these primary markets are lower than they were before the war, and in the case of corn, our largest grain crop, the price at Chicago is lower than the average price at this time for the past 15 years, while on the farms in the heaviest producing States the prices are lower than for 25 years.

LAND PRICES AND RENTS.

The four years 1916-1919, inclusive, were prosperous for farmers in general. Prices of grain, live stock, cotton, and wool were relatively high, and thrifty farmers got money ahead. These higher prices caused a large advance in the price of farm land. Not all of this was due to farmer buying. The shrewd trader and speculator scented some easy profits and bought to sell again. Also promoters of easy business virtue deliberately set snares for unwary purchasers and induced them to go over-heavily in debt for land bought at prices which included unfair profits. Many young farmers who had saved several thousand dollars during the prosperous years were induced to buy farms on contract at the price peak, making small payments down, with provision for yearly payments of interest and on the principal on pain of forfeiture of all sums previously paid. The sadly unprofitable year of 1920 wiped out thousands of these fine young men, and the even worse year of 1921 will finish more of them.

During the prosperous years land rents went up rapidly, doubling and trebling, and in some cases going even higher. It was human nature that renters should prefer to pay cash rent in a time of good farming profits. The drop in prices for crops in 1920 caused many of these renters to lose not only their labor for that year but their savings as well. But for the leniency of their landlords thousands upon thousands of other renters would have lost everything they had.

DIFFICULTIES OF PRODUCERS A MATTER OF NATIONAL CONCERN.

The cynical or thoughtless man is disposed to say: "What have I to do with all of this? Those unfortunate purchasers and renters exercised bad business judgment. They took their chance and lost. They are simply victims of business misfortune. The same sort of thing will happen to me if I show no better judgment. Of course, I am sorry to see them lose, but really it is no affair of mine."

Nevertheless it is a matter of concern to the Nation at large and it is the affair of every good citizen when any considerable number of hard-working men get into financial difficulties so serious that their ability to produce is impaired. And surely it is a matter of concern to the community at large when the food producers of the Nation so generally find themselves in a condition not only financially unprofitable but which threatens continued production.

The unprofitable year of 1920 compelled large numbers of farmers to borrow heavily to meet excessive costs of production, which could not be paid for out of crop proceeds. Interest rates were high, and through our ill-adapted system of credit for farmers' needs, particularly in such times, most of these loans had to be renewed every 90 days. The unprecedented drop in prices of farm products in 1920 came as a stunning surprise to the majority of farmers. They had expected some decline, but nothing so severe as what actually happened. Consequently for a time they tried to avoid heavy sacrifice and continued their borrowings. Their bankers shared their belief that the situation would adjust itself and were willing to lend, but prices went lower, and these loans, together with loans previously made, soon added volume to that mass of frozen credit of which we have heard so much talk during the past year.

CONTINUED PRODUCTION DEPENDS ON FAIR PRICES.

So we find that, speaking generally, the economic conditions which affect agriculture are in a bad state, with ruinously low prices for

grains, with farmers laboring under heavy financial burdens, and with their difficulties having been communicated to practically every other line of industry, commerce, and general business.

In setting forth this situation so candidly, my thought is not to add to the discouragement but rather frankly to bring the situation with all its difficulties clearly into view. The condition must be recognized exactly as it is if it is to be alleviated. Ignorant optimism is just as harmful as doleful pessimism. We must accept the cold fact that agricultural production in adequate measure can not be continued any length of time on a basis which does not give the producer a fair price. If conditions continue under which workmen in other callings, whether laboring men, skilled workmen, manufacturers, or business men generally, receive pay which is so very much higher than the farmer receives, there will be a steady drift from the farm to industries and business, thus increasing the number of consumers and decreasing the number of producers, and this will result in prices for farm products so high that conditions will be reversed and the burden will be transferred to the people in the cities. It is not to the advantage of the Nation that any large group of our people be placed at an economic disadvantage.

Fortunately, there is a brighter side to the picture I have presented. Prices for live stock are much higher relatively than prices for grains. In the case of corn, for example, which is our largest grain crop, the farmer is receiving very much more for this grain when fed to hogs and cattle and sheep and marketed in that form than he is receiving for his corn when marketed as corn. Speaking generally, about 80 per cent of our corn crop is fed to live stock, and those farmers who have maintained their live-stock production are not suffering so severely as might be indicated by the price of grains. The prices of dairy products also are higher relatively than the prices of grains and feeds, and in those sections where dairying is practiced there is a steady income and the farmers are getting along.

The cotton crop of 1920 was large, and when the foreign outlet was so restricted prices dropped far below the cost of production. The situation was so serious throughout the cotton States that the bankers, merchants, and business men generally joined with the farmers to bring about a reduction in the acreage in 1921. This effort was successful, and the acreage was reduced about 28 per cent.

The crop was still further shortened by the ravages of the boll weevil, so that the final figures will indicate a reduction of nearly 50 per cent below last year's production. When this situation became known there was a rapid advance in the price of cotton. The price doubled within a period of a few weeks. The effect was beneficial not only to the cotton planters and others who held old cotton, but to all business interests in the South, and reports from that section have been much more hopeful during the past two months.

CONSTRUCTIVE LEGISLATION BY CONGRESS.

The market decline in the prices of farm crops during the fall of 1920 was noted with some satisfaction by the consuming public. Although prices of farm products on an average had not increased as much as the prices of most other commodities and had not increased as much as wages in industry, nevertheless our people had been accustomed to cheap food for so long that any increase in price, whether actual or relative, met with indignant protest. The drop in prices paid to the farmer, however, was not followed by a corresponding drop in the prices which the consumer paid for his food-stuffs, and before the summer was well advanced the thinking business public began to see that the severe drop in the prices the farmer received was having a very bad effect upon business and industry in general and that such a marked reduction in the purchasing power of the farmer might result disastrously. When Congress met in April, 1921, the danger to our agriculture was in the minds of Senators and Representatives, especially those from the agricultural States, who had first-hand knowledge of the situation, and there was an earnest casting about for measures of relief. Many bills were introduced in the hope of helping the farmer. Members of the staff of the Department of Agriculture were called into council on these measures.

Much time was given to the preparation and submission of statistical matter and other information asked for by legislators. It became evident that there were no short cuts by which an immediate return to agricultural prosperity could be insured, but some laws were enacted which already have had a helpful influence. Most of these were directed toward making credit more easily available for worthy borrowers. The joint-stock land banks were helped back into busi-

ness by the measure which authorized them to increase the interest rate on their bonds issued based on farm loans. The power of the War Finance Corporation was greatly extended, making large sums available for agricultural needs. The machinery for getting out these loans is now working well and most helpfully in the surplus-producing States. Provision was made for increasing the capital of the Federal farm land banks, thus enabling them to extend their farm-mortgage loans, and the better demand for bonds based on these loans is making rapid extension possible. An act was passed bringing the packers and market agencies under Government supervision, and another act extending Government supervision over grain exchanges. Never in the same length of time did Congress give more serious attention to farm needs.

All of this legislation is of a constructive character and will be more helpful than is now realized. Concerning the efforts to make easier credit conditions, there is this to be remembered: Better prices for the crops the farmers have to sell and lower prices for the things they have to buy are far more needed than an opportunity to go further in debt. Easier credit will be helpful mainly in enabling the farmer to tide over this period of severe stress without being compelled to sacrifice his live stock and crops and without losing his farm. Money made available through the new facilities provided by legislation should be used mainly for carrying loans on which payment is demanded and for buying live stock to consume the surplus crops. If loan companies and insurance companies which hold farm mortgages will freely grant extensions of payment of both principal and interest, that will help conditions very much, and they can do this without danger of loss.

As is always the case in such periods of depression, many well-meaning men come forward with ill-considered measures. Visionary schemes of all kinds are presented. Some would have the Government take charge of the larger business enterprises; others would have the Government undertake to fix prices either arbitrarily or indirectly by buying up surplus crops. The experience of 3,000 years shows the impracticability of such efforts.

Much is to be hoped for from the agricultural inquiry which has been under way since midsummer by a joint committee of the Senate and House. The department has aided this committee in every way

possible, and especially by preparing a great mass of statistics bearing on the economics of agriculture. The result of the committee's studies should be very helpful in enabling us to plan wisely in the future.

MUST CONSIDER ECONOMICS OF AGRICULTURE.

In addition to contributing what it could of helpfulness to Congress and to other agencies seeking means of relieving the uncomfortable situation, the department has been working earnestly in its own field. Agents have been sent to Europe to study conditions there in the hope of finding ways to enlarge our exports of farm products. We have not met with large success in this direction because of economic conditions abroad. Continued inflation overseas and drastic deflation at home put us at a decided disadvantage in selling our products. However, much exceedingly helpful information has been gained, which, while not promising the full measure of immediate relief we would like, will help us to plan more wisely and to adjust our production more perfectly to the foreign demand. The effect upon our agriculture of economic and financial policies put in force by nations which import foodstuffs has not had the attention in this country which the matter merits.

Had we in the past given as much attention to the economics of agriculture as we have to stimulating production, it is not too much to say that at least some of the troubles which now beset us might have been anticipated and avoided. Firmly convinced of this, one of my first acts upon taking office was to inquire into the economic work being carried on in the department. I found this mostly in two bureaus and one office of bureau standing. Last winter Congress provided in the agricultural appropriation act for the consolidation of the Bureau of Crop Estimates and the Bureau of Markets. In considering this consolidation I found that to secure the greatest efficiency in our study of economic problems it would be wise to include in this merger the Office of Farm Management and Farm Economics as well. To make sure that nothing might be done without due thought, I appointed an economic council, consisting of five bureau heads, and asked them to consider the economic work of the department and make their recommendations. After much study and investigation this economic council prepared a report. Several highly qualified men from different parts of the country were then

asked to come to Washington and go over the plans submitted. They did this and approved the plans, which contemplate the consolidation of the Bureau of Crop Estimates, the Bureau of Markets, and the Office of Farm Management and Farm Economics and the rearranging of the work of these three bureaus under appropriate divisions. Not having authority to formally complete such consolidation, I consulted with various members of the agricultural committees of the Senate and House, and upon receiving their approval ordered that the work be so arranged as to virtually effect the consolidation. In the estimates for the next fiscal year I have asked legal authorization to complete it.

NEW BUREAU TO MEET NEEDS.

I have suggested that the name of this new bureau should be the Bureau of Agricultural Economics. It is proposed to merge into this one bureau all the forces of the department which are engaged in agricultural economic work. The purpose is to inquire into every economic condition and force which has an influence upon either production or price, for the one depends upon the other. We shall begin with the study of farm management, types of farming, cost factors, market grades, and practices as they bear on farm management. The cost of production and distribution will be studied at each stage along the way. Investigations will be made in land economics with a view to encouraging a wholesome system of land tenure; land resources and utilization; land settlement and colonization; the marketing of farm products with a view to better organizing distribution; market conditions, standardization, and grading of products; collection of statistics of production and distribution; crop and live-stock production both in the United States and in foreign lands; prices of farm manufactured products; historical and geographical studies in production and distribution with a view to interpreting the trend of agricultural prices and production, the development or decline of markets, and generally the geography of the world's agriculture; methods of finance; insurance of buildings, live stock, and stocks in storage; taxation and its relation to production and distribution; the financing of rural public utilities and other group enterprises; agricultural conditions in countries which compete with the United States; the characteristics and changes in rural home life and its relation to agriculture; the trend of agri-

culture and population; in short, everything which may be helpful to the farmer in producing with judgment. Such studies and investigations will be just as helpful to the consumers as to the producers, for the ultimate purpose is to make sure that our people are abundantly supplied with the products of the soil at prices which will both sustain our agriculture and be just to the consumer.

Much of the work outlined above already has been under way in the department, some of it for many years, but I am sure that this bringing together in one bureau of the major economic projects of the department will both reduce expense and make possible the better working out of these projects.

The organic law which created the department back in the sixties contemplated exactly this sort of development. By it the department was charged with the duty of acquiring and diffusing "information on subjects connected with agriculture in the most general and comprehensive sense of that word." The thought that the sole duty of the farmer is to produce and, having produced, take his crops to the nearest market, sell them for what he can get, and then go home and produce some more, is no longer entertained by well-informed men. It is now generally recognized that the farmer has a very direct and personal interest in the efficiency with which his crops are handled until they reach the consumer's table. The production of food has long been considered as a sacred obligation, but it is an obligation not in any sense more binding than the obligation to get that food to the consumer with the least possible waste and at the least possible cost. Nor is the obligation to produce more binding than the obligation to produce intelligently with due regard to the needs of consumption. It is just as important that the producer know what to produce and how best to get it to the consumer as it is to know how to produce at all.

MARKETING IS PART OF PRODUCTION.

Marketing is as truly a part of production as is the growing of the crops, for the crops have no value unless they can be put into the hands of those who need them. The assembling, storing, and distributing of farm products are productive enterprises and those engaged in this work require much the same economic and technical information as that required by farmers. The acquiring and disseminating of knowledge of what to produce and how best to market

it is as much needed as the knowledge of how to produce, whether the matter is viewed from the standpoint of the farmer, the middleman, or the consumer, for orderly and stabilized production means prices which are neither very much too high nor very much too low and guarantee an abundance of food at all times. Such knowledge can not be gained from a study of the mechanics of marketing alone. It is much more than a business matter. It involves research in agronomic, biological, and physical, as well as statistical and economic science by men trained in their respective lines and who have a working knowledge of agricultural processes and conditions.

AGRICULTURAL RESEARCH INVOLVED IN MARKETING.

To learn what it is wise to produce involves study of the varieties, qualities, and quantities demanded by the market. In the case of fruit, as an illustration, this requires the selection or the breeding of suitable varieties by the horticulturist; a study of life processes by the plant physiologist; the study of liability to attack by bacteria and fungi by the plant pathologist. Thus it may involve the cooperation of horticulturists in breeding suitable varieties with physiologists in the study of their behavior and with plant pathologists in the study of their liability to disease. All these are factors in the bringing to market of a large variety of agricultural products.

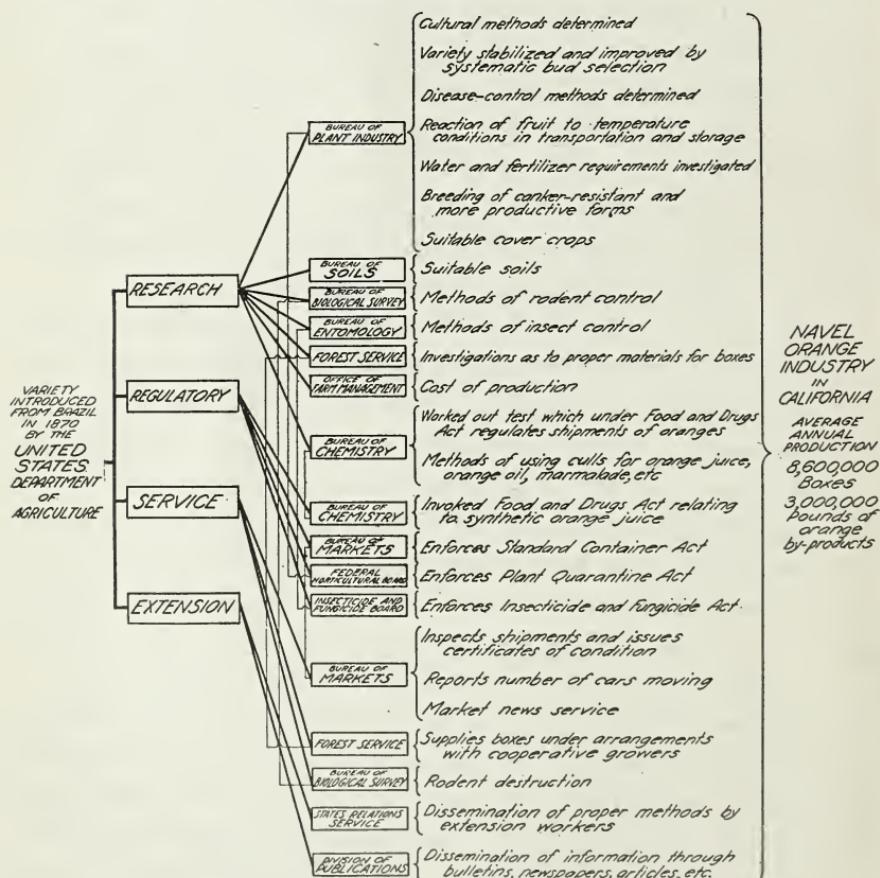
Practically all agricultural products are more or less perishable and good marketing involves more than mere salesmanship, more than a mere determination of the public taste, the public demand, and the probable supply. Only through the carrying out of investigations in marketing of the type above described, in which horticulturists, plant physiologists, plant pathologists, chemists, refrigeration experts, and statisticians have cooperated, has it been possible to give to American agriculture that distinctive character which makes it possible to produce perishable products on one edge of the continent and to market them without serious deterioration upon the other.

A very good illustration of the way in which the various forces of the Department of Agriculture are mobilized and used to successfully create a great new industry is found in the story of the Washington Navel orange. Back in 1870 the department first brought this variety to the United States from Brazil. The introduction consisted of 12 newly budded trees. These were planted in the department greenhouse in Washington. One of the original trees is still growing



there. The first two young plants propagated from these were sent to Mrs. L. C. Tibbets, Riverside, Calif., in 1873. When these trees came into bearing the high value of the variety was promptly recognized, and then began its development for market. The accompanying chart shows in graphic form how the services of the scientists of the different bureaus of the department were utilized to establish this new industry from which there is now an average annual production of 8,600,000 boxes of oranges and 3,000,000 pounds of orange by-products. This is but one of many stories which could be told of the service the department is rendering to the Nation.

DEVELOPMENT OF NAVEL ORANGE INDUSTRY



STUDIES IN GRAIN MARKETING.

In the marketing of grain, investigations are necessary on the milling and baking qualities of wheat and other grains for the purpose of determining the relation or intrinsic values of such factors as test weight per bushel, gluten content, color, texture, general appearance, different forms of damage and mixtures of various impurities, and treatment to which grain is subjected in handling.

All this is necessary in order not merely that grain may be properly graded but also that the most suitable kinds of grain may be bred, introduced, and grown. This work has the profoundest effect on farm operations.

The cereal breeders in the department, particularly those engaged in the breeding of wheat, work with those engaged in the studies of grain markets and standards. In order that a new variety may be readily acceptable to the farmer and to the grain trade it must be determined before it is distributed that it meets the demand of the market. Otherwise it would be no advantage but an actual detriment to introduce a new variety of wheat which yields more than the variety a farmer is now growing but which has a poorer milling quality, so that he would receive a lower price for it on the market. Therefore, the plant breeder and the market specialist must work together to see that only those varieties are distributed which are at least as good as the varieties now generally grown.

All along the line there needs to be the closest cooperation between department scientists who are familiar with varietal adaptation and the rapid changes taking place in the varieties grown by farmers and those who have to do with marketing and particularly those concerned in formulating and administering grain standards. The rapid increase in the growth of red durum wheat made it necessary to introduce new standards for that class of wheat.

Diseases play an important part in determining the market grade and value of cereals. The presence of smut in any considerable quantity is always noted in grading wheat and the price materially reduced because of it. The shriveling of wheat caused by rust and the presence of moldy and rotten ears and spoiled kernels in corn, due to corn rots and other diseases, materially affect the grade and market value of those grains. Therefore the work of research specialists, either in developing methods of controlling the disease or in

producing resistant varieties, is of importance not only to farmers but to the grain trade and to consumers. It is necessary that the biological research workers be closely in touch with those who are studying grain marketing and grain standards, so that the latter may be advised of outbreaks of new diseases or the occurrence of extensive epidemics of diseases already well known.

Crop rotation and farm management affect the presence of mixtures of other grains and of weed seeds and are therefore important factors in determining the grade of grain sold by farmers. Practically every phase of research has its bearing upon marketing and benefits both producer and consumer.

LAND UTILIZATION STUDY.

Considering the future, the need of basic research in agricultural economics becomes even more manifest. We produce more food-stuffs than our own population can consume, and under present conditions we are suffering because of the lessened foreign demand which leaves it on our hands. This, of course, will not continue. The world will weather this period of reconstruction and trade back and forth will be restored. Our own population is increasing rapidly, and within a very few years home needs will require most of what we grow. We can not increase our land area. We now have under the plow practically all the land that is easily available for cultural purposes. We can add to our productive areas by reclaiming wet land, by clearing cut-over land, and by irrigating dry land. These additions must be made at considerable expense and can be made wisely only after thorough study of the character of the land, its location as to markets, and its adaptability to produce what the market needs.

I have assigned to a committee of highly competent men from the several bureaus of the department the task of making a survey of our land area which is not now being utilized for the production of crops. They will study the dry lands, the wet lands, and the cut-over timberlands especially with a view to determining how such lands can best be used to increase agricultural production as needed. We must have reliable information concerning these lands if we are to develop a wise agricultural policy.

The largest increase in production, however, must come not from the addition of new land but from increased yields on the land now under the plow. This means a tightening up of production methods.

Increased production ordinarily increases cost and our efforts should be, therefore, to cheapen production as well as marketing costs. We will be driven to this by increasing competition from foreign farmers in countries where fertile land is still very cheap and where the standards of rural life are not as high as we demand for our own people. Until very recent years this foreign competition was not a serious matter. Our own land was relatively cheap, and our farmers are the best in the world measured by the standard of production per man. Now, however, with land at prevailing prices our farming in the future must be conducted on much more business-like lines and in such a way as to return a fair income one year with another. Deferred income resulting from large and rapid increase in farm land values is very nearly a thing of the past.

Without lessening in any way our efforts to produce more cheaply and better, we must give the most painstaking attention to studies of what we may call the business side of farming, such as have been mentioned in discussing the proposed Bureau of Agricultural Economics. Our steadfast purpose should be to maintain the agricultural basis of this Nation, to maintain and advance our relatively high standards of rural life, and to conserve the fertility of our soil through a well-balanced system of agriculture. Under a carefully thought out agricultural policy embracing these essentials there need be no question of our ability to feed our people abundantly and at reasonable cost.

ORGANIZATION OF THE DEPARTMENT.

Turning now to the general work of the department, it is organized by bureaus, scientific and administrative. A hasty glance at this organization might give the impression that these various bureaus are to some extent unrelated in their organization and work. Quite the contrary is true. The activities of each bureau are not limited to the apparent boundaries of that bureau but are extended to aid other bureaus. Some reference already has been made to this in what has been said on the subject of marketing. The solution of the varied problems affecting agriculture requires the combined efforts of men in many scientific fields.

The functions of the department are carried on in four general fields of endeavor—research, extension, regulation or supervision,

and service. These fields, while distinct in themselves, nevertheless imperceptibly merge into one another and the workers pass back and forth as needed, just as the farmers of a community change work with one another or come together to perform a task too large for the individual.

RESEARCH THE BASIC WORK OF THE DEPARTMENT.

Naturally, the basic work of the department is in the field of research. Upon the results of this work its other activities are built. For the first 40 years its chief business was in this field. A staff of scientific specialists was built up who made studies of the soil, of plant cultural methods, of the breeding and feeding of animals, of plant and animal diseases—of everything which had to do with crop and live stock production. It is this scientific research which contributes the material that little by little is crystallized into agricultural progress. Through this work of the department in cooperation with the various State experiment stations the Nation is richer by thousands of new varieties of plants introduced from other lands or created by scientific breeding. Plants have been discovered which are better adapted to our colder climates, our arid regions, our higher altitudes; disease-resistant strains and drought-resistant varieties have been developed; methods of control of diseases of plants and animals have been discovered; the science of bacteriology and animal pathology has been created; and a protecting and ever-vigilant army has been organized around the sources of our food supply.

To try to tell the story of the year's work in research would be a hopeless effort in a report of this kind. It will be found in detail in the numerous scientific publications and bulletins printed by the department and in the reports of the bureau chiefs. At the present time research work is being carried on in some 2,500 different lines of investigation, in some by one bureau alone, in others by the cooperation of several bureaus.

Among the more important of these investigations a very few may be mentioned:

Development of a new process for manufacturing phosphoric acid to eliminate the immense waste now suffered in mining phosphate and thus reduce the cost of fertilizers.

Development of a method for separating the microscopic colloidal particles in soils, which is expected to throw light on such agricultural problems as cultivation of soils, the amount of water required by certain soils, their capacity for retaining plant foods, and their reaction to lime.

Development of better methods for fixing atmospheric nitrogen for use as fertilizer.

The soil survey has completed the mapping of soils over an area of 1,063,588 square miles, including 31,915 square miles in Alaska and 300 square miles in Porto Rico. The work covers approximately 950 counties and 50 reconnaissance areas.

Investigation of corn root, stalk, and ear rots to determine the causes and methods of preventing these obscure and widespread diseases.

Investigations of the effect of light, and more especially the length of the day, on plant development, furnishing explanations of phenomena in plant growth not heretofore understood and essential to accurate experimentation in the breeding of plants for economic purposes.

Development of methods of accurately measuring the productivity and other important characteristics of perennial plants, such as fruit trees, through bud selection, which will make possible the replacement of undesirable trees with desirable types of the same variety.

Experiments looking to improvement of the milking quality of beef cattle.

Practical completion of experiments which have resulted in the establishment of a breed of general-purpose fowls which lay white-shelled eggs.

Breeding experiments which will lead to the fixing of a type of American utility horse.

Studies to ascertain the cost of producing various farm crops and the cost of marketing them.

Studies to throw light on the whole marketing problem as a basis for the more efficient organization of the various marketing processes, whether the work is done by individuals or by groups of farmers.

Research to determine the composition of agricultural products in order to develop new uses for cull and surplus crops.

Basic research on the composition of foods and drugs in order to establish standards to prevent adulteration and to improve methods of manufacture.

Research to develop methods of chemical analysis for the use of chemists in agricultural colleges, experiment stations, universities, and those connected with Federal, State, and municipal food and drug departments.

The development of measures for the control of the European corn borer, the Japanese beetle, the pink bollworm of cotton, and other crop pests that have recently gained foothold in this country.

Researches to determine the characteristics of materials designed for highway construction.

Researches to determine improved methods of highway design to meet modern traffic conditions.

Studies of hydraulic problems, including the factors influencing run-off and flow of water in drainage canals.

MONEY SPENT IN RESEARCH IS NATIONAL INVESTMENT.

It is impossible to estimate the value of this research work. The money spent for it is capital invested by the Nation in building a permanent agriculture. Its dividends come from increase in yields, decrease in cost of production and marketing, and better utilization of crops, all having for their purpose the maintenance and increase of our food supply.

Last spring Congress very wisely authorized the appointment of a Director of Scientific Work. This will make it possible still further to coordinate the work of the various bureaus and also to bring the scientific work of the department into closer relation with the scientific work being carried on in the experiment stations of the different States, as well as to cooperate with various other agencies engaged in similar or related lines of investigation. Such cooperation should result in a well-rounded national program of research, a larger and better directed program than we have had in the past, and a much better utilization of both time and money.

In the carrying out of this policy there is need for the strengthening of the work of the State experiment stations by increased Federal appropriations. These stations are receiving about \$3 of State appropriation to \$1 contributed by the Federal Government, but even

with this help they have not been anywhere near able to keep pace with the calls for information and investigation resulting from the rapid development of the extension service. As the research of these stations and the Federal department are the sources from which the information to be carried by the extension service is derived, it is of the utmost importance that the research service be strengthened so as to adequately meet the demands for information. The Federal Government can well afford to be liberal in appropriating money to the State experiment stations to be used in research work planned in cooperation with the department.

As an aid to the research and other work the department maintains a library, which was increased during the year by the addition of 7,500 books and pamphlets. The collection now contains 160,000 books and pamphlets, a large number of which can not be found in any other library in the country.

AGRICULTURAL EDUCATION.

The importance of extending and improving agricultural instruction in schools is fully recognized by the department, and the Congress has for a number of years made provision for investigations on this subject. The purpose is to make available to teachers and students the agricultural knowledge accumulated here and by the agricultural colleges and experiment stations. The department cooperates with the Federal Board for Vocational Education, as provided for in the Smith-Hughes Act, with the States in preparing courses of study in elementary agriculture for rural schools, and with teacher-training divisions and teachers in service.

In cooperation with the Federal Board there have been prepared a number of courses of study on agricultural subjects, especially for the use of teachers in vocational agricultural schools operating under the Smith-Hughes Act.

Through State cooperation two courses of study in elementary agriculture, based on a study of the agricultural practice in the respective States, were prepared during the past year, one for the rural schools of Arkansas and the other for the rural schools of North Carolina. Some special assistance was given the Department of Education in Ohio in the form of suggestive outlines for rural teachers.

Circulars suggesting how teachers may profitably use information contained in certain publications, particularly the Farmers' Bulletins of the Department of Agriculture, are prepared from time to time with the hope of improving methods of instruction in agriculture and related subjects. Five such circulars were prepared during the past year, dealing with such subjects as beautifying the homestead, better seed corn, cowpeas, forage for the cotton belt, and factors that make for successful farming in the South.

The schools are also aided by the loan of illustrative material, especially sets of lantern slides adapted to school use, and by the distribution of classified lists of publications of the Department of Agriculture, as well as lists of sources of materials valuable to teachers of agriculture.

In all this work it is recognized that the teaching of agriculture in a community should have a vital connection with the problems of the farms of that community. Pupils are interested in those things with which they come in contact, and it is believed that the type of agriculture practiced in the community can be used to the best advantage in teaching. Therefore the teacher is urged to organize the available subject matter which is of community interest and present it in such a manner that it will touch closely the life and experiences of the pupils.

HOME ECONOMICS.

While other branches of the Government study certain phases of food, clothing, and household equipment, the Department of Agriculture is the only one specifically concerned with investigations relating to the selection, preparation, and care of these commodities in the home. These are matters of importance to agriculture in two ways—first, because the final utilization of agricultural products is an essential part of the economics of agriculture, and, second, because the welfare of a farm family depends upon how wisely it uses the materials, money, and labor available for household needs.

The Department of Agriculture during the past year, as in previous years, continued to carry on investigations on food, clothing, and household equipment and management, with particular reference to assisting extension workers in improving conditions in the farm home. The constantly increasing number of requests received for reliable information on all such subjects proves the desire of Amer-

ican housekeepers to apply the results of scientific research to their household practices just as farmers have come to demand a scientific basis for agricultural methods.

The department has found it impossible to meet all the legitimate demands for such information made upon it by extension workers, other branches of the Government, public and private institutions, teachers, and individuals, and has therefore found it necessary to confine its efforts to a limited number of the more pressing problems which it is especially well equipped to study, which seem most generally urgent, or regarding which there is the least available information.

DEPARTMENT ADMINISTERS MANY LAWS.

The regulatory or supervision work consists of the administration of a large number of laws such, for example, as the food and drugs act, which forbids the adulteration or misbranding of any article of food or drugs entering interstate commerce; the meat inspection act, which insures the wholesomeness of our meat; the protection of the national forests; a number of quarantine acts dealing with live stock and with plants; the protection and commerce in game animals and migratory birds; the manufacture of serums and toxins; the insecticide act; the tea importation act; the enforcement of grain and cotton standards; the Federal warehouse law; the act prescribing standards of size of boxes and baskets used in the packing and selling of fruits, berries, and vegetables; the Federal road act; the packers and stockyards act; the future trading act. Through the administration of these and a number of other laws designed to protect our people from impure food and unfair weights and measures the department comes into very direct contact with the business and consuming public throughout the country. These laws are administered with a view to aiding legitimate industry and, at the same time, protecting the public from unfair practices on the part of those few whose business ethics are not as high as the public interest demands.

The administration of each law has been placed in the bureau that has to deal with the scientific and constructive work concerning the subjects affected by the law. Experience has shown that a law affecting commodities manufactured from a given agricultural raw material can be most constructively enforced by the organization that is familiar with the production and handling of that raw material. If

the law is of such nature as to affect a range of commodities or subjects so wide as to go beyond the purview of a single bureau, it is administered by a board made up of specialists from the different bureaus having to do with the scientific investigation of the subjects involved. An example of the former kind is the meat-inspection law, which is a matter primarily for veterinarians. Examples of the latter are the plant quarantine act, which equally concerns plant physiologists, entomologists, and foresters; and the insecticide and fungicide act, which is of equal concern to plantsmen, animal husbandmen, and entomologists. But even those acts that come wholly within the purview of a single bureau require for their proper enforcement the cooperation of scientists in other fields of agricultural research. The enforcement of the food and drugs act, for instance, constantly calls for the cooperation of chemists, of botanists, of biological scientists in the fields of animal industry, and of various other specialists who are employed by the department primarily to perform other duties but without whose aid the enforcement of the food and drugs act would become so wooden and autocratic as to become obnoxious alike to producer and consumer.

REGULATORY WORK STIMULATES RESEARCH.

It has been found that the regulatory work strengthens the research work, because in the regulatory work problems are discovered that are of the utmost importance to the welfare of the country and which can be turned over to the scientific research staff for solution. Thus, the regulatory work is a source of stimulus for the research staff. Some of the most valuable practical work that has been done by bureaus having laws to enforce has grown out of information gained in the regulatory work. If the bureaus had not had the regulatory work to deal with, the problems would not have come to the attention of the scientific staff.

There is still another class of regulatory work consisting of the administration of laws that are permissive rather than mandatory in nature. An example is the United States warehouse act. The duties growing out of such administration are perhaps more accurately described as service than as regulatory work, but they none the less act in the same stimulating manner upon the scientific work.

The department reported during the year to the Department of Justice 6,514 civil and criminal cases arising under the various regu-

latory statutes committed to its administration and enforcement. Notices of judgment were filed in 2,275 cases involving the adulteration and misbranding of foods, drugs, insecticides, and fungicides.

PACKERS AND STOCKYARDS ACT.

During the past summer Congress added to the duties of the department by placing under it the enforcement of the packers and stockyards act and the future trading act. These laws give the supervising agency large powers.

In the case of the act first named the packers are prohibited from any unfair, unjustly discriminatory, or deceptive practices or devices; from giving undue preference; from apportioning the supply of any article with the effect of restricting commerce or creating a monopoly; from manipulating or controlling prices; from apportioning territory or purchases or sales. Commission merchants, persons furnishing stockyard services, and dealers at yards are required to establish, observe, and enforce just, reasonable, and nondiscriminatory rates. They are forbidden to charge other rates than those named in schedules which they are required to file for approval with the supervising agency, and the latter after hearing may determine and prescribe just and reasonable rates and make appropriate orders and enforce same. The act carries suitable penalties. The packers, stockyards, and market agencies may appeal to the courts if their rights are infringed.

Under the terms of this act it should be possible both to correct any unfair practices in the marketing of live stock and to make a constructive study of the business of marketing live stock and distributing meats.

The organization for the administration of this act is now being built up as an independent unit in the department. Great care is being taken to select men who have general knowledge of the live-stock industry and of marketing and packing, and who are level-headed, even-tempered men, free from prejudice.

GRAIN EXCHANGE SUPERVISION.

The future-trading act imposes a prohibitive tax of 20 cents per bushel on future-trading exchange transactions known to the trade as "privileges," "bids," "offers," "puts and calls," "indemnities,"

or "ups and downs." It also provides for a tax of 20 cents per bushel upon grain sold for future delivery, except when the seller is the owner or the grower of the grain, or the owner or renter of land on which it was grown, or an association of such owners or growers, or owners or renters of land, or when such contracts are made by or through a member of a board of trade which has been designated by the Secretary of Agriculture as a contract market. It provides that all such contracts must be evidenced by a memorandum in writing containing essential information. The Secretary of Agriculture is authorized to designate boards of trade as contract markets under certain conditions set forth in detail in the law, which conditions provide for adequate Government supervision of such markets. The Secretary of Agriculture is authorized to make such investigations as he may deem necessary concerning operations of boards of trade and may make rules and regulations calling for the information necessary to make such investigations.

Under this act it should be possible to make a thorough study of the operation and effect of future trading in grains, and it is hoped that after a time this information may make it possible to do away with unfair manipulation in prices of grains if such is found to exist.

CONFIDENCE SHOWN IN EXTENSION WORK.

The extension work of the department is designed to carry to the farms the results of its research activities. This is done through co-operative arrangement with the agricultural colleges and experiment stations through the agricultural agents who are now working in more than 2,000 counties, as well as by means of the very large number of bulletins in which the application of the work in research is presented in popular form and thus made available to the individual farmer. During the year the two offices of extension work, one for the South and the other for the North and West, have been consolidated. It is expected that under this arrangement some money may be saved and that even more efficient work will be done than in the past.

Confidence in the extension work is strikingly shown by the steady increase of local funds for the support of the extension agents. During the past year about \$16,800,000 were available from Federal, State, and county sources, and of this amount \$5,900,000 was con-

tributed by the county governments and farm organizations. This year the total funds will be about \$18,500,000, of which \$6,900,000 comes from sources within the county.

SPECIAL WORK AMONG NEGRO FARMERS.

The special work among the Negro farmers of the Southern States has been fully maintained. Not only have the white agents taken an increased interest in aiding the Negroes, but the number of Negro agents has been somewhat increased. There are now 157 Negro men and 91 Negro women employed in the county extension work, together with two unusually capable Negro men employed by the States Relations Service as general field agents. In the States the responsibility for the administration of the Negro work rests on the State agricultural colleges which conduct the work among the white farmers, but the State colleges for Negroes cooperate as far as practicable in this branch of the extension service. The work among the Negroes has had very useful results in improving both agriculture and race relations, but is at present reaching only a small fraction of the Negro farm population. It should be extended more rapidly.

WORK AMONG FARM WOMEN BROADENED.

The work among the farm women has been considerably broadened of late and is based more definitely on careful studies of the actual requirements of farm homes and the varying character of the problems which need immediate attention in different regions. It now includes many things relating to the farm home food supply, diet of children and adults, clothing, household equipment and management, care of children and the health of the farm family, as well as the encouragement of agricultural production by women and girls, where this is needed to increase their income or to supply their families with a more varied and healthful diet. In the recent public discussion concerning pellagra and other diseases due to malnutrition, the fact was largely lost sight of that in many thousand southern homes the families had better health because under the guidance of the home demonstration agents the women and girls had good gardens, raised poultry, and kept dairy cows, either doing all the work themselves or enlisting the assistance of the men and boys. There has also been increasing cooperation of the extension agents with the

Federal, State, and local health services, the Red Cross, and private associations dealing with the affairs of rural communities.

The boys' and girls' club work continues to have well-merited popularity and is a great inspiration to many thousands of our farm children. In many cases their achievements in the production of excellent crops and animals serve as examples which the adult farmers are very glad to follow. This work is leading an increased number of farm boys and girls to see the advantages of technical education in agriculture and home economics, so that former club members are now found in considerable numbers in our schools and colleges where these subjects are taught.

AGENCIES EMPLOYED IN EXTENSION.

Some of the agencies through which the extension work is carried on are:

Two thousand four hundred and twenty-five persons engaged in county agent work in approximately 2,000 of the 2,650 counties having enough agriculture to employ an agent. The total number of the counties in the United States is about 3,000.

Nine hundred and fifty persons engaged in home demonstration work in 725 counties.

Three hundred and five persons engaged in boys' and girls' club work.

Special extension workers in farm management and farm economics.

Special dairy extension workers.

One thousand two hundred and sixty Farmers' Bulletins and 1,037 technical and scientific bulletins covering practically all phases of the department's work have been issued up to date.

Press service to approximately 17,000 publications, including newspapers, agricultural journals, trade and professional journals, church papers, magazines, etc.

Exhibits at agricultural expositions and fairs.

Motion pictures, which are furnished free for exhibition at various kinds of agricultural gatherings.

The Assistant Secretary of Agriculture was chosen with especial reference to his experience in extension work, in addition to his general qualifications for the position. He has been assigned to general supervision over this work and already has under way plans for the

coordination of the various extension activities, including the publication and information work. I feel sure that under his guidance this work will be greatly strengthened during the coming year.

There is a growing feeling in the department and in the State extension divisions that more attention should be given to a unified extension program for the entire farm family and less to separate divisions of work along the lines of sex and age. This consideration will be kept in mind in the contemplated reorganization plans. It also seems wise to give more attention to a national program of agricultural progress. We hope to give the States more material aid along this line.

SERVICE WORK CARRIED ON.

In what might be called the field of service is included such work as the crop-reporting service, the market-news service, the weather service, and many others. These activities are neither research nor extension, strictly speaking, although their field is greatly extended by research, and knowledge of the work is spread through the extension service. Other services, such as are connected with the forestry administration, for example, grow out of research and have certain phases of a regulatory nature, but are very largely protective to the interests involved.

Some of the important lines of service work are:

Weather forecasts, covering not only general conditions but having particular application to various specialized industries, agricultural and otherwise.

Crop reports, designed to afford equal opportunity to producers and buyers to judge of production and, therefore, of demand.

Market-news service, covering both staple and specialized crops.

Meat-inspection service, certifying the wholesomeness of all meat and meat products entering interstate or foreign trade.

Inspection service, available alike to producer and distributor, by which the condition of fruits and vegetables and other food products is definitely fixed at the time of shipment or of arrival at destination.

Inspection service for the War Finance Corporation.

Inspection of certain food supplies for the Army and the Navy.

An office of development through which the discoveries of the research workers are made available to the industrial world.

Aid in improving the quality of their output to manufacturers using agricultural products as raw materials.

The following periodical publications are issued in connection with these services:

Daily.—Weather map; market reports as follows: On butter, cheese, eggs, and dressed poultry; on perishable fruits and vegetables; on meat-trade conditions and wholesale prices; on live-stock markets; and a general market-news service.

Weekly.—National Weather and Crop and Snow and Ice Bulletin; Market and Crop Reporter; market reviews as follows: On butter, on cheese, on meat-trade conditions, on live-stock markets, on peanuts, a carlot summary by States.

Semimonthly.—Report on honey and beeswax.

Monthly.—Weather Review; export report; report on fluid-milk market, condensed-milk market, and powdered-milk market; summary of cold-storage holdings of frozen and cured meats and of frozen and mild-cured fish.

Quarterly.—Production report of certain dairy products and oleomargarine.

STAMPING OUT PLANT AND ANIMAL DISEASES.

The warfare carried on against plant and animal diseases calls for the combined efforts of the research scientist, the extension specialist, and those who have to do with certain regulatory measures. When a new and dangerous plant pest gains lodgment within the country its presence first is detected by the scientist. He makes a study of its life history, if such is not already known, of its natural enemies, if it has such, of its host plants; in short, seeks all possible information that may be of use in fighting it. This knowledge is taken to the farmers in the community in which the pest has appeared and its danger thus made known. A campaign of eradication is then organized, or, if not eradication, then a campaign to check the spread of the pest. In the case of many plant and animal diseases eradication has been found practicable. This is carried on in cooperation with the States, but can be successful only under the authority of the Federal Government which may be exercised in different States.

The possibility of entirely eliminating a pest or disease from our country is an entirely different problem from that of carrying on investigations to limit its injury. For example, the ravages of the

codling moth increase the cost of producing apples in an amount averaging about 10 per cent for the whole country. The untreated orchards suffer a direct loss in fruit of from 40 to 80 per cent, or even a total loss, depending on the severity of the infestation. Proper spraying and caring for orchards may reduce the direct loss to a minimum, but the cost of doing this then becomes the burden, and this cost on the average is not far from 10 per cent of the cost of production of the apple. If by the expenditure of any reasonable sum of money this pest could be entirely eliminated from a region or from the United States, it would be worth an enormous sum of money, as it would obviate the expense of fighting it, as well as increase the production of sound fruit.

The cotton boll weevil destroys \$200,000,000 worth of cotton annually. Any program that offered a reasonable possibility of success in eradicating this pest would warrant the expenditure of many millions of dollars.

ERADICATION DEPENDS UPON RESEARCH.

It is only through the most effective kind of scientific research and thorough organization that any such ambitious eradication programs as above suggested could be carried out. On the other hand, when a new insect pest or plant disease suddenly appears in a small area in the country the expenditure of a relatively large amount of money in a concentrated effort toward its eradication may entirely eliminate what would otherwise be a constant menace to the industry threatened. The foot-and-mouth disease has invaded this country several times, and each time by prompt and vigorous action and the expenditure of a few million dollars the entire live-stock industry, aggregating many billions in value, has been protected from this scourge. Should it once get away from us, eradication would be impossible. In the same way the prompt and efficient attack on the citrus canker in the Gulf coast region resulted in the elimination of a disease that threatened the entire industry. The total cost of this effort to date has been less than \$3,000,000, while the actual destruction caused by the pest during its brief period of injury was many times that amount, and if unchecked it would have entirely eliminated one of the most valuable industries of that region. These are examples of the possibility of success of prompt and effective service. There is always a possibility of failure, and

such failures have occurred, notably in the case of the chestnut blight and the white-pine blister rust. These were due to the fact that the diseases were far more widespread before they were discovered than was realized at the time the effort was made. The expenditure of the money was, however, abundantly justified in the possibility that it offered of success. If the chestnut blight had been discovered in time we would still have our chestnut trees. As it is, they have been practically destroyed.

Two other eradication programs are just now in critical stages. The pink bollworm is one of the most serious cotton pests that the world has known. A considerable part of America's success in cotton production has undoubtedly been due in the past to the fact that we did not have this insect to contend with, while nearly all of the competing countries were infested. It has obtained a considerable foothold in Texas and Louisiana. The next year or so will determine whether the campaign of the department to eliminate it is to be a success or not. If successful, the cotton industry will be in a favorable situation. If the pest escapes into the large cotton-growing regions, it will then be but a question of holding it to the smallest possible areas, with the practical certainty that ultimately it will reach the entire cotton-growing region.

In anticipation of the possibility of such misfortune trained men have been sent to cotton-growing regions in other countries to study cultural methods which may be followed to reduce the damage done by this pest. Similar work has been successful in the fight against the boll weevil. As a result of the research applied to cotton during the period of the boll-weevil invasion it has been possible to develop superior varieties and improved methods of cultivation that greatly reduce the injuries or make good the losses that the boll weevil inflicts. Most rapid progress in growing the improved varieties is made in communities which devote themselves, under a plan of community organization, to the production of a single variety.

The gipsy moth has been present in Massachusetts for many years. Owing to the favorable direction of the prevailing winds the department has been enabled to hold this pest from spreading to the south and west. During this period a number of new infestations—mainly from European shipments—have been discovered in different parts of the United States. These have been promptly attacked and in

every case have been eradicated. A little more than a year ago a serious infestation was found in New Jersey which had evidently been there for a number of years and had increased to an alarming extent. This outbreak is a serious menace to the entire forest, shade, and fruit tree industry throughout the eastern area. The same winds which have been so favorable in helping to hold the New England area in check will undoubtedly sweep this infestation northward and eastward if unchecked until it will devastate the entire New England region. Special appropriations have been granted for the purpose of eradicating this infestation, and a two hundred thousand dollar increase is being requested in the regular appropriation for the next fiscal year to continue this work. It is hoped that by aggressive action this outbreak may be confined to its original area and rapidly reduced until it is completely eradicated.

STEADY PROGRESS AGAINST ANIMAL SCOURGES.

There are other types of eradication work, such as the fight against the cattle tick, in which the work goes on year after year, making steady progress. The tick-fever line has been pushed gradually southward until it appears that within a very few years the entire United States will be freed from Texas fever, which has greatly retarded the progress of live-stock production in the South. It is worthy of note here that this program was made possible through discovery by the scientists of the department of the transmission of the fever by the cattle tick, a most valuable contribution to our knowledge of the transmission of many other diseases of animals and of human beings.

The practical means of eradicating tuberculosis in animals also originated in the discovery of a scientific test by which the presence of the disease is revealed. The use of this test makes possible the elimination of this dread disease. To begin with, it was used by a limited number of breeders of pure-bred stock who desired to free their own herds from disease. Then a plan for cooperation by the Federal Government, the States, and the owners of cattle was worked out by which all the cattle of a community might be tested and the diseased ones eliminated. Were it possible to prosecute this work more vigorously there seems good reason to believe that the live stock of the country could be freed from tuberculosis. Unfortunately, sufficient Government and State funds are not available to prosecute

this campaign as rapidly as live-stock owners wish. The Federal Government appropriated \$1,000,000 to be used for partial indemnity during the year beginning July 1, 1921. This was to be paid only when States contributed an equivalent amount. Before four months of this fiscal year had elapsed the allocation of Federal funds had been exhausted in a number of States, and here the warfare against tuberculosis must practically stop unless further appropriations are made. With one exception, it is believed that every State to which Federal money has been allotted for this purpose will have used all of those funds before the end of the fiscal year. It is unfortunate that adequate sums are not available now. Cattle are cheap, the public interest is aroused, and the work of eradicating tuberculosis would go forward most satisfactorily were the funds at hand.

The common barberry, the bush which carries the black stem rust of wheat from one year's crop to another, is being eradicated from 11 of the upper Mississippi Valley States, the great wheat belt of the United States. This is another campaign that is now under way and has already reached the stage in which it is consolidating areas from which the pest has been eliminated. Unexpected difficulties have arisen from time to time in this as in other eradication campaigns. Considerable areas of wild barberries have been discovered in a number of places that were undoubtedly responsible for much of the injury of the years past. Sporadic outbreaks of rust appeared in the wheat fields in this area last season, but no general epidemic, such as appeared in 1916, has occurred since the beginning of the barberry removal campaign.

The eradication of predacious animals which have been so destructive to the live-stock interests of the western regions, as well as the eradication of prairie dogs, ground squirrels, and other rodents, which have annually been destroying the grass and grain crops on vast areas, are other programs which are in a formative stage. Already some of these campaigns have reached the point of extermination over large areas, and as time progresses and the people come to recognize the value of this work undoubtedly the areas will be extended and a general extermination of some of these pests undertaken.

FURTHER RESEARCH NECESSARY TO ERADICATION.

The hog-cholera control program has not yet reached the eradication stage. More scientific work must be done before it will be pos-

sible to put the handling of this disease on the same footing with tuberculosis eradication. It is one of the most serious menaces of the live-stock industry and it is to be hoped that a method of absolute control may be speedily found.

There is no more fertile field in the range of scientific endeavor than that offered by the possibility of eradication of destructive insects and plant diseases. Pests and diseases not only cause great losses but make much more difficult the effort to adjust production to the needs of consumption. A considerable number of live-stock pests and a number of the worst pests of our cultivated crops are so limited in their food habits or in some stage of their life history that it will be possible to apply eradication methods whenever conditions appear favorable. Most eradication campaigns require a preliminary period of education in the possibilities and opportunities of accomplishment before those interested are willing to cooperate to the extent necessary to make them successful. Most of the failures of eradication campaigns for introduced pests have been due to the lack of understanding of the serious nature of the situation until it was too late for effective work. The cotton boll weevil could have been eradicated any time during the first five years of its invasion of the United States for a relatively small sum if the cotton growers had only realized the danger that was impending and had been willing to conform to the control measures recommended by the department's scientific staff. On the other hand, the eradication of a pest of long standing which the people have come to consider a necessary evil may be very difficult, owing to lack of faith in the possibility of the program and a consequent lack of cooperative endeavor.

RECORD MADE IN ROAD CONSTRUCTION.

During the past year more improved roads were built under the Federal-aid road act than during any similar period, the mileage completed being more than three times as great as the entire mileage completed during the preceding years under the act. At the end of the fiscal year 1920 a total of 1,677 miles of Federal-aid road had been completed, and there were 14,940 miles additional under construction and reported as about one-third complete. During the fiscal year 1921, 7,469 miles were completed, and at the end of the year there were 17,977 miles under construction.

Including the completed work on the projects still under construction, the States were entitled to draw Federal funds to the amount of \$118,915,515. In addition there was a balance allotted for projects under construction but not yet earned to the amount of \$66,375,636. The total amount of Federal money in projects completed or under construction at the end of the year was, therefore, \$185,291,151, or about 70 per cent of all the money made available to the States from past appropriations.

Of the \$266,750,000 which was available to the States the unobligated balance was but \$18,793,544. Twelve States had no balance remaining due them. Nine States still had to their credit more than a million dollars unobligated. The remaining States had varying amounts of less than a million dollars still unallotted to definite projects. Under the law these allotments must be taken up by the States before June 30, 1923; otherwise the amount remaining will revert to the Federal Treasury for redistribution among the States.

ECONOMIC CONDITIONS ENCOURAGE ROAD BUILDING.

There has been marked improvement during the past year in the economic conditions affecting road work. Rail transportation for needed material has been more satisfactory. Contractors have been glad to undertake new work at lower prices than before, and the increasing unemployment of labor in industries has made a larger supply of labor available for road work at much lower wages. Encouraged by these improved conditions, many States have been offering contracts for large sections of road improvement.

The task of keeping roads in repair is becoming increasingly difficult. Traffic steadily grows and carries heavier loads, and because of this old methods of annual repair will not suffice in the future. Nothing short of constant and systematic attention, involving the immediate repair of defects as quickly as they appear, will maintain our highways in good condition. In the past the Federal Government has not been able to control maintenance, although, as a rule, the States have acted in good faith, and at the close of the year all completed roads were in satisfactory condition. Most of these roads, however, were new and will require far more attention in the future.

NEW ROAD LAW.

The new Federal highway act passed by Congress in the fall of 1921 is believed to be the most constructive road legislation ever enacted in this country. It carries an appropriation of \$75,000,000

for the fiscal year ending June 30, 1922, of which \$25,000,000 is immediately available, and provides that unexpended sums allotted to any State shall be available to such State until June 30, 1924, after which any unexpended balances shall be reapportioned to the various States. In the average State this money is expended in the proportion of \$43 from the Federal Government to each \$57 provided by the State. Each State must have a properly organized and equipped State highway department. Projects for road improvement must be submitted by the State and be approved by this department before Federal money is available. The State is required to designate a system of highways not to exceed 7 per cent of the total highway mileage of such State. This selected system shall be divided into two classes, one to be known as primary or interstate highways, which shall not exceed three-sevenths of such system, and the other to be known as secondary or intercounty highways, which shall consist of the remainder of such system. Not more than 60 per cent of Federal-aid money shall be expended on the primary or interstate highways except with the approval of the State highway department, and the States are required to make provision of State funds for construction, reconstruction, and maintenance of all Federal-aid highways, which funds shall be under the direct control of the State highway department.

Only such durable types of surfacing as will adequately meet existing and probable future traffic needs and conditions may be included as part of the 7 per cent system, and all such construction must have the approval of the Secretary of Agriculture. In States having large areas of Government land provision is made for larger relative Federal aid.

ROAD MAINTENANCE INSURED BY NEW LAW.

The matter of maintenance seems to be safeguarded by this new law in a thoroughly satisfactory way. It is provided that if the State fails to maintain any highway which has been improved through Federal aid, the Secretary of Agriculture shall bring this delinquency to the attention of the State. If within 90 days such highway has not been placed in a proper state of repair, the Secretary shall proceed to have it placed in such condition and charge the cost thereof against the State's apportionment of Federal-aid funds. He shall also refuse to approve any additional projects in the State until the State has reimbursed the Federal Government for the

amount of Federal-aid money spent for such maintenance work. The Secretary is authorized to have such maintenance work done as may be necessary. Responsibility for maintenance, therefore, can not be avoided.

An appropriation of \$5,000,000 for the fiscal year 1922 and \$10,000,000 for the fiscal year 1923 is made for building roads in the national forests.

The Secretary of War is authorized and directed to transfer to the Secretary of Agriculture upon his request war materials, equipment, and supplies now or hereafter declared surplus from stock suitable for use in highway improvement, and this material may be distributed to the States on the same basis as Federal aid funds are distributed, as much as 10 per cent being reserved for Federal use in road construction.

RESEARCH PROBLEMS IN ROAD CONSTRUCTION.

The Secretary of Agriculture is authorized to set aside and retain 2½ per cent of the total appropriation, to be used in administering the act and in conducting highway research. The importance of such research is increasingly evident. The demands of our highway traffic are becoming more severe. The increasing use of large motor trucks presents maintenance difficulties unknown a few years ago. The Department of Agriculture is conducting many scientific investigations with a view to improved road construction, and especially to determine the effect of vehicular impact on road surfaces. Short stretches of roads of different types are being built and submitted to the most severe traffic tests. The department also is cooperating with the various State highway departments and scientific institutions in similar investigations. It is not too much to say that the research work already done has yielded more precise scientific knowledge of highway construction and maintenance than we have ever before possessed. When we consider the enormous sums which are now being expended annually for road construction, the relatively small provision made for research work should bring exceedingly large returns.

The foregoing is a very brief outline of the more important provisions of the new Federal aid act. Under the wise administration of this act first-class road construction should proceed as rapidly as is wise and safe.

SURPLUS WAR MATERIAL FOR ROAD WORK.

Under previous acts of Congress large quantities of surplus war materials have been distributed among the States. But for the use of this material the work of the State highway departments under the difficult conditions of the past two years would have been almost impossible. This equipment was bought by the Government for use in war and the distribution of the surplus for road work, now that its need for war purposes no longer exists, is making available for the use of the taxpayer simply a return for the money he has provided. Up to the end of the fiscal year approximately \$130,000,000 worth of this material had been transferred, including \$11,000,000 worth which has been retained by the Department of Agriculture for use in connection with its various road-building activities. Approximately 27,000 motor vehicles were included in the material that has been distributed. As was to be expected, much of this surplus material was in bad condition and some of it not fit for further use. The cost of distributing the material is borne by the States. Organization for intelligent distribution and use of these materials is being improved steadily.

THE NATIONAL FORESTS.

Until recent years the forests of the United States were looked upon as the gift of a beneficent Creator, ready prepared for the harvest, for the profit of those individual citizens to whom they were most freely parceled out by a liberal Government. While Federal funds were appropriated for forest investigations in 1876, the first forest reserves were not created until 1891, and not until 1905 were the national forests formally designated as such and placed under the administration of the Department of Agriculture. Only since the date last named has there been a definite national forest policy. It was high time. Of the more than 800,000,000 acres of original forest area there now remain but 137,000,000 acres in virgin forest, and more than half of the remaining timber supply is in the West Coast States, which means that the lumber must pay a heavy transportation charge before it reaches the large consuming regions.

The cutting of these virgin forests was done wastefully and with little thought of growing a second crop of timber. It was a question of immediate profit, not future need. This has resulted in a staggering loss in timber production and has imperiled our future sup-

ply of wood. More than this, in mountain areas the evil extends to soil erosion steadily increasing in volume and destructiveness, and irregularities in streamflow ranging from excessive floods to excessive periods of low water. The denudation of mountain lands under private misuse has much to do with our difficulties in maintaining the navigability of streams and preserving regular sources of water supply urgently needed for irrigation. Recognition of this danger brought about the establishment of our national forests, which now aggregate 156,000,000 acres, equal to one-fifth of our timber-growing land.

NATIONAL FOREST POLICY.

The forest policy which has been developed by the Department of Agriculture since the forests were placed under it contemplates:

First. The administration of the national forests in such a way as to promote the greatest possible utilization for all purposes and at the same time the greatest possible growth of timber. This includes protection from fire, regulation of cutting, tree planting, and forest management to secure the maximum growth of timber; full utilization of forage resources for live-stock raising; classification of lands and the elimination of areas most suitable for farming; the use of lands for a wide range of purposes, including industrial developments and recreation; the fullest possible development of water powers; the readjustment of boundaries to include forest lands and to exclude other lands. While the national forests are being administered as national property, the well-being of local communities, which are largely agricultural in character, is a primary consideration.

Second. The extension of the national forests through the purchase of lands which will protect the watersheds of navigable streams. The national forests established by Executive order or by legislation now cover the headwaters of nearly all the important streams beyond the Mississippi and protect enormous investments in irrigation works, irrigable farms, and hydro-electric development. They are now slowly being extended by purchases over the watersheds of navigable streams in the eastern States and should be extended still further as rapidly as possible. This policy represents to-day the most striking application of public foresight to land problems in the history of the United States.

Third. Scientific research with a view to—

(a) Ascertaining and demonstrating through the activities of forest experiment stations the cheapest and most effective methods of growing the maximum timber crops of the best species.

(b) Products investigations centered mainly at the Forest Products Laboratory at Madison, Wis., to ascertain and demonstrate means of preventing waste and the most effective means for the manufacture and utilization of our forest resources. These investigations are designed to extend the life of our present resources, reduce to a minimum the production necessary to meet future requirements, and indirectly to make the growing of timber more profitable.

(c) Investigations of timber resources, the extent of forest lands, and other economic questions, such as timber taxation, in order to secure the data which must underlie the development and application of a national-forest policy.

Fourth. Dissemination of information, and cooperation with States, timberland owners, and farmers, in the protection and management of public and privately owned forests and farm woodlots. These activities include—

(a) Fire protection through cooperation between the Federal Government, the State governments, and private owners.

(b) Cooperation with the management of privately owned timberlands to check their devastation and assure the continued use for timber growing of lands not better suited for other purposes.

(c) The dissemination of information which will make possible greater and better production on the 200,000,000 acres of farm woodlots owned by the individual farmers of the Nation. Woodlot products now rank in value as one of the first three or four principal farm crops of the country. The yield of these farm woodlots can be immensely increased by better methods.

(d) Publicly owned forests with the greatest additions which can be anticipated can not alone meet our requirements for wood. The department is therefore attempting by all means at its disposal to secure the adoption of a national policy for the production of timber on the privately owned lands most suitable for this purpose.

CONSERVING THE FORESTS.

During the 16 years the Department of Agriculture has administered the national forests it has secured and trained an administra-

tive force remarkable for its efficiency. Methods of cutting timber have been developed under which the forest reproduces naturally, and these requirements have been so harmonized with the practical limitations of lumbering that the demand for national-forest timber has grown steadily. The condition of the national-forest ranges has been very greatly improved and at the same time the stock which they can support without damage has been increased by approximately one-third. A system of fire protection has been established which has stimulated fire protection throughout the United States and is serving as a model to State and private agencies alike. In general, all national-forest resources have been brought into use. Western public sentiment, at first decidedly hostile, now almost universally supports the present form of administration, and western stockmen have even gone so far in many instances as to demand the extension of the national-forest system of range management to the remaining public grazing lands; in short, the national forests are now vindicated by their fruits.

Some 2,000,000 acres of forest lands have been purchased at the headwaters of navigable streams in the East, and these areas have been placed under an administration comparable with those of the western forests. Favorable progress in purchases was made during the past year.

Forest products investigations, which at their initiation were ignored by the forest industries of the country, have through the demonstration of their benefits permeated the forest industries almost without exception and have given an entirely new conception of the possibilities in the conservation, manufacture, and utilization of forest products. A beginning has been made in the establishment of forest experiment stations which should as rapidly as possible be extended to cover at least all the principal forest regions of the country. Notable contributions have been made to our knowledge of remaining timber supplies and related economic subjects.

Information on the need for timber growing and the best methods for growing and utilizing timber have been widely disseminated. Public opinion has been aroused until now there is a powerful Nation-wide support for the adoption of a national policy which will bring about the growing of timber on privately owned lands to supplement that which can be produced on national forests and other public holdings.

PROTECTION FROM FIRE.

Through the example of the national forests the Forest Service has extended the work of fire protection over the forested areas of one-half of the States of the Union. In its earlier work the efforts of the Forest Service at controlling forest fires often met with ridicule as being hopeless or impossible. Last year 24 States cooperated with the Federal Government in forest-fire protection. This year the fund for cooperation with the States was raised from \$125,000 to a new total of \$400,000. The larger appropriation has greatly stimulated local effort along the same lines. The protection of forests against fire is a problem in which there are three parties in interest—the owner, who hopes to sell the timber; the local public, whose carelessness is the cause of part of the hazard; and the Nation, through its interest in navigation and general welfare. Efficient fire protection will contribute largely toward the solution of the problem of our future timber supply. Through its efforts in building up a system of fire protection in cooperation with the States the department is making excellent progress. There should be no break in the continuity of this work.

BETTER UTILIZATION OF FOREST PRODUCTS.

The basic function of the Forest Service is to bring about the utilization primarily for timber growing, and incidentally for a wide range of other purposes, of the one-fourth of the land area of the United States best adapted to this purpose in the same way that other units in the Department of Agriculture attempt to bring about the most complete utilization for agricultural production of the part of the remaining three-fourths which is most suitable for this purpose. The Forest Service is a part of the Department of Agriculture primarily because of this basic use of land. It is related to the department, further, in the utilization of some 156,000,000 acres of national forests for the grazing of live stock, a strictly agricultural function which involves cooperation with both the Bureaus of Animal Industry and Plant Industry. It is related in the extension of road and trail systems on the national forests in the interests of agricultural communities as well as to provide communications for fire protection and for general administration, and this involves cooperation with the Bureau of Public Roads. It is related in the development of forestry on the 200,000,000 acres of

woodlots owned by farmers and cooperates in this function with the States Relations Service and its widely extended organization of county agents. In its research activities the Forest Service cooperates with practically every other bureau in various economic investigations; with the Weather Bureau, in investigations on the relation of forests to stream flow and the general relations of climate to forest growth and fire protection; with the Bureaus of Animal and Plant Industry in a wide range of investigations covering both utilization of the national forests for grazing, the work of the forest experiment stations, and finally, the protection of forests and forest products from fungous diseases.

FOREST MANAGEMENT AN AGRICULTURAL PROBLEM.

Investigations to reduce enormous losses through decay of pulp wood and wood pulp were conducted jointly by the Forest Service and the Bureau of Plant Industry. Cooperation with the Bureau of Entomology and with the Biological Survey cover both insect and animal attacks on forest growth. In perfecting plans for controlling an insect infestation on forest lands under its jurisdiction the Department of the Interior has recently found it advisable to agree that the work should be handled by the Forest Service working in co-operation with the Bureau of Entomology. The Bureau of Soils assists the Forest Service in the studies of soils and their bearing on the life of forest trees and forage plants, and further, in land classification for agricultural homestead settlement. The Bureau of Crop Estimates secures information on the needs of stockmen and farmers for public and national forest ranges which aids the national forest administration, and collects also data on the products of farm woodlots which is of value in the development of farm forestry. In short, having largely exhausted the forest crop grown in advance, the problem now is to use more widely what remains and to grow other crops to meet our needs. That is to say, forestry is a distinctly agricultural business. The function of the department as a whole includes efforts for the production and the most effective manufacture, distribution, and utilization of the products of both farm and forest for the benefit of the country at large. Finally, the agricultural industry itself is the largest owner of timberlands and the largest user of forest products, and as such is vitally interested in the administration of the forests.

PAPER MAKING IN ALASKA.

Worthy of special mention is the progress which has been made in calling the attention of capitalists and newsprint manufacturers to the splendid opportunities offered by the two great national forests in Alaska for the establishment of an important industry in that region. The Tongass National Forest, situated in the southeastern part of the Territory, has a stand of not less than 70,000,000,000 feet of timber within its area of about 15,000,000 acres. The Forest Service, after a careful study of these resources and a scientific determination of the value of such Alaskan timbers for purposes of paper manufacture, has divided the forest into 14 development regions, each one of which contains sufficient water power potentialities and sufficient timber to run a large paper-manufacturing plant permanently. It is estimated that under the plans now worked out the two national forests in Alaska can furnish *perpetually* 2,000,000 cords of pulpwood annually, amounting to an equivalent of one-third of our present consumption. Two large sales have already been made and one small mill erected. It is confidently anticipated that extensive development along these lines will take place as soon as financial and industrial conditions become normal. The problems of forest administration in Alaska are inseparably linked with similar problems encountered in the States, and an efficient, decentralized, local administration has been established which is functioning in close coordination with the other scientific bureaus of the department.

THE DEPARTMENT IN ALASKA.

The service rendered by the Department of Agriculture in Alaska is exactly the same sort of service that it renders in the various States and Territories, modified, of course, to meet local conditions. It maintains in Alaska nine stations of the Weather Bureau. The Biological Survey has four stations which give attention to the reindeer and land fur-bearing animals. The Forest Service, as has been noted in dealing with its activities in this report, has charge of the large national forests there. The Bureau of Public Roads handles forest-road construction under the Federal-aid act. Extension work through the States Relations Service is carried on from five different agricultural experiment stations scattered through the Territory. Through these activities the people of Alaska have the same benefit

from the work done by the Department of Agriculture as have the people of the States.

Because of the distance the representatives of the department in Alaska have been given larger powers than representatives in the States. The effort has been to delegate the largest possible authority in order that prompt decisions may be made on the ground.

BETTER HOUSING NEEDED FOR DEPARTMENT.

The offices and laboratories of the department are scattered in more than 40 buildings in various parts of the city of Washington. This results in waste of a tremendous amount of time and money for which the Government must pay. Efficiency is impaired by difficulty of personal contact between the Secretary and the officers of the department, as well as between bureau chiefs and units of their own respective bureaus. Many units which are closely related organically are so separated by the exigencies of housing space that much confusion exists and full and efficient utilization of the services of the workers is impossible. The necessary transmission of mail and packages between so many scattered locations requires a very large messenger force, while the guarding of these scattered buildings, by day and night, necessarily entails a force of watchmen much larger than would be needed for a smaller number of suitable buildings properly located. In addition it is a source of constant embarrassment to the department that visitors who have business to transact with the Government must be referred from building to building, frequently from one part of the city to another.

Of the buildings owned by the Government and occupied by the department, several are of the temporary type, erected hurriedly during the war, highly inflammable, and otherwise unsuited to the work of the department. The same is true of some of the rented buildings. In several of these buildings the valuable property and records of the Government are continually exposed to the risk of fire, and there is even apprehension of loss of life.

The prompt construction of a large modern office building for the use of the various scattered units of the department should be a profitable financial investment and would add immensely to the efficiency with which its work is carried on.

CAPABLE LEADERSHIP ESSENTIAL IN DEPARTMENT WORK.

The most important single problem before the department at the present time is that of securing and holding the right kind of leadership in its different lines of work. The possibility of economically and efficiently carrying out a given project depends upon the vision and resourcefulness of the individual assigned the task. He must have technical training requisite to meet all the intricacies of the situation, administrative ability sufficient to organize and lead his force, and a personality that will win confidence and respect. Individuals having all these qualities are rare, but once secured are the very foundation of an efficient scientific organization. With this type of leadership in all divisions of the work the highest possible efficiency can be secured with a minimum expenditure of funds.

On the other hand, with a leadership lacking in training or vision the essential point of an investigation or the fundamental principle which gives value to another type of service may be neglected and the entire expenditure may accomplish little or nothing of permanent advantage. With adequate training and the proper personal qualities but without administrative ability the project may be prosecuted with the right objective but be ineffective and wasteful in operation.

In research work it is doubly important that the project leader possess these qualities, for much of our research is of such a nature that it is difficult or impossible for those not familiar with the problems involved to determine whether the methods employed are such as to finally secure the desired results. Great importance is therefore attached to reliance and dependability in leadership. In recommending in its estimates for the next fiscal year advancement in salaries for certain of the administrative leaders of the department, and especially in recommending the increase in the maximum possible to pay scientific workers from \$4,500 to \$6,500, the department is acting solely from the standpoint of economy and efficiency in the expenditure of these funds. A given amount of money wisely expended will accomplish very much greater results than double that amount used in the maintenance of an organization without a definite aim or purpose.

NEED FOR BETTER SALARIES.

The situation as to salaries grows worse each year. Efficient leaders in the different lines of the department's work are one by one leaving

the service to accept employment at higher rates of compensation or under more favorable circumstances. The salaries in the Department of Agriculture were fully comparable with those in the better grade of educational and research institutions before the war period. Since that time these institutions by the pressure of commercial interests and higher wage standards in other lines of effort have advanced their salary scale from time to time until now many of the endowed institutions, such as Columbia, Yale, Harvard, Stanford, and Chicago, are paying professorial salaries of from \$7,500 to \$10,000. Harvard, for example, pays the heads of all its departments from \$6,000 to \$8,000. These salaries promise to be increased rather than diminished.

In the same way the State-supported institutions have raised their salary standards until such institutions as Wisconsin, Minnesota, Illinois, Ohio, and California are paying from \$6,000 up. When a single institution like Chicago or Wisconsin has 125 professors receiving an average salary quite a little above \$5,000, it is not difficult to see why the department has trouble in retaining its bureau chiefs with an average salary of \$4,700 and its project leaders with an average salary of \$3,500. The bureau chiefs should rank in training and experience and in professorial qualities with college presidents. In fact, two of them have refused such presidencies within the past year. The project leaders of the department have larger administrative responsibilities and should have higher qualifications, on the average, than the deans and directors of our educational institutions whose salaries average from \$1,000 to \$2,000 higher than those of the professors of the corresponding institutions. A number of the former employees of the department are receiving salaries ranging from \$10,000 to \$20,000 in commercial positions. Loyalty and opportunity for great public service has held many a scientific worker in the department against a flattering offer from the outside, and because of that spirit it will always be possible for the department to hold its workers at a lower salary than the maximum paid by the educational institutions and for very much less than that offered in the commercial fields. If, however, any satisfactory degree of permanence is to be secured, it will be necessary to reach a salary standard whereby these men will be enabled to maintain a reasonable standard of living for themselves and their families with a small

surplus to supplement the totally inadequate retirement provisions of the present time.

If the department is to go forward in its work and meet the increasingly complex problems of the future it must have authority to pay fair salaries. In research work the loss of a scientist not only imperils the leadership of the project but inevitably in leaving he takes with him a knowledge and experience gained at the expense of the Government, which is only to be acquired by his successor by long and painstaking effort; so that even if an equally strong man could be secured the loss through the lack of continuity of the work is usually much greater than the increased outlay that would have been necessary to have insured the continuous services of the individual. From every standpoint, therefore, the high turnover in scientific personnel that the department has been experiencing in recent years is uneconomical and wasteful.

The proposed program of cooperation and correlation of scientific work of the department and the State stations calls for an even higher type of leadership on the part of the department. In order to make such projects feasible and to properly equip the organization for an effective attempt to attack the more fundamental problems which have up to the present time resisted the efforts of isolated workers, such permanent leadership must be secured.

HIGHLY TRAINED SCIENTISTS A NATIONAL ASSET.

The great discoveries of the ages have been made by exceptionally gifted individuals, and the nation that can produce such individuals and provide for the concentration of their efforts on the problems of most vital interest to national welfare will be successful in the competition of the future. The experience of the war period has amply demonstrated that when the leading scientists of the Nation were called together for the solution of a given problem success was practically assured. The trend of movement of population and civilization in the past few centuries has been toward the center of food production. This tendency will undoubtedly increase. It would therefore seem but the part of wisdom to make adequate provision for leadership and efficiency in matters so vital to national welfare.

GRADUATE WORK IN DEPARTMENT.

To maintain continued efficiency in a scientific organization under civil-service regulations some provision must be made for adequate training of those who enter the service in the lower positions. The rapid turnover in personnel during the war and post-war periods has resulted in an extremely rapid advancement of these men. To meet this need the department has provided for graduate training in various lines for the scientific workers. The work is given outside of office hours, is supported entirely by the students, and is therefore unofficial in nature. It is, however, supervised and encouraged by the department. The workers are allowed to take only one course at a time, and everything necessary is done to insure the highest standard for the work, so that it will not only be effective training for the department workers but satisfactory to the graduate institutions of the country. It is expected that the ambitious workers of the department will make arrangements with such graduate institutions for the acceptance of these credits and will ultimately attend these institutions and complete the work required for advanced degrees. Leaves of absence for this purpose are being arranged and closer cooperation with graduate departments in the solution of research problems is being considered.

Some of the strongest scientists of the department are taking charge of courses and a few of the leading graduate institutions have furnished teachers for others. Altogether a most helpful spirit has prevailed. It is expected that other graduate institutions will from time to time assist the department in its efforts and that the scientific men detailed to temporary appointments in Washington may be available for this service.

Although just getting under way, this increased opportunity is already being reflected in the greater enthusiasm and loyalty of the workers within the department. The most hopeful aspect of the situation, however, is the fact that the ambitious students of the best institutions are again becoming interested in the possibilities and opportunities of Government service. The lack of adequate salary standards and opportunity for obtaining advanced training have made it difficult for the department to attract to its entrance positions in the past the very men who are absolutely essential to the continued efficiency of its work. It is hoped that provision for higher salaries

in the advanced positions and enlarged opportunities for graduate work may help us overcome this difficulty.

CONCLUSION.

In the foregoing I have tried to present truthfully the adverse conditions affecting our agriculture at the present time and the bad effect these conditions are having upon industry and business. The troubles by which the farmer is surrounded are not of his making. In large part they are due to world-wide conditions over which he had no control and the inevitable result of the World War. It is not to be expected that by some miraculous transformation this period of adversity may be turned overnight into a period of prosperity, but there seem to be good reasons for believing that the worst is over and that we may reasonably hope for gradual improvement from now on. A clear recognition of the conditions as they exist should help us to realize this hope.

When finally we emerge from this distressing period we shall find ourselves at the beginning of a new agricultural era. Heretofore we have produced more food products than were needed by our own people. We had land in abundance and of great fertility. Our population is increasing rapidly. We have taken up most of our easily cultivated land. We are not far from the time when home needs will require practically all that we produce in the average year. This means a more intensive agriculture, with larger production per acre and lessened cost, if we are to meet foreign competition and still maintain our standards of living.

The Department of Agriculture is planning to meet these new conditions by strengthening its work in certain directions. Its appropriations from the Federal Government are set forth in the pages which follow. A study of the regular appropriations will show that very nearly two-thirds of the money is spent for regulatory and service work which is of more direct value to the consuming public than to the producers on the farm. The money made available for scientific research and its application to farm problems should be increased in the national interest. As has been said, such money is in the nature of an investment. It results in vast additions to our national wealth. The amounts asked for the coming year, and which have been approved by the Bureau of the Budget, have been reduced

to the minimum. In the future these appropriations should be increased just as rapidly as the organization and administration of the department gives reasonable assurance that increased money will be used wisely.

It is planned during the coming year to strengthen certain phases of the work of the department, more especially the scientific research, the application of the results of research to farm practice, more extended studies of marketing farm crops with a view to reducing cost, investigations of both production and consumption at home and abroad for the purpose of better adjusting our own production to market needs, and studies looking toward making available to the farmer those devices of modern business which provide needed credit on easy terms and which may help us to distribute production risks more equitably.

This is a creative department. Also it is a department of service. Its task is to conserve and increase national wealth through the wise utilization of the soil and its products, having in mind constantly the maintenance of the fertility of the soil for the use of the generations to follow us.

In such a task the department should have both the liberal financial support of the Government and the sympathetic interest of all our people.

Respectfully,

HENRY C. WALLACE,

Secretary of Agriculture.

The PRESIDENT.

APPROPRIATIONS.

The cost to the Federal Government of the research, extension, service, and regulatory activities of the department during the fiscal year 1921 was approximately \$32,000,000, as indicated by the following table:

Federal appropriations available for regular work of department.

Agricultural appropriation act, 1921-----	\$31,712,784.00
Less-----	
Appropriations for State agricultural experiment stations-----	\$1,440,000.00
Smith-Lever supplementary funds -----	1,500,000.00
Short-time rural credits-----	5,000.00
Immediately available appropriations expended during 1920-----	11,868.00
	2,956,868.00
	\$28,755,916.00
Agricultural appropriation act, 1922, immediately available for expenditure during 1921 (exclusive of \$2,000,000 for seed-grain loans to farmers)-----	218,300.00
Deficiency appropriation act, Mar. 1, 1921-----	1,153,000.00
Deficiency appropriation act, June 16, 1921 (exclusive of \$125,000 for printing and binding)-----	496,000.00
Permanent annual appropriation for meat inspection-----	3,000,000.00
Protection of lands involved in Oregon and California forfeiture suits (Forest Service)-----	25,000.00
Balances of appropriations from prior years-----	3,130,972.49
Printing and binding fund (sundry civil appropriation act, 1921, and deficiency appropriation act of June 16, 1921)-----	850,000.00
Total available-----	37,629,188.49
Unexpended balances, June 30, 1921-----	2,847,303.90
Actual expenditures from Federal funds-----	34,781,884.59
Less receipts, 1921, deposited in U. S. Treasury (see p. 60)-----	2,514,879.37
Net cost of regular work-----	32,267,005.22

In addition, the following special funds were available for work incident to the department's regular activities:

Special appropriations from receipts.

Roads and trails for States (construction and improvement of roads and trails within national forests)-----	\$892,492.09
Paid from national forest receipts for fiscal year 1921 (see p. 60)-----	\$472,025.24
Balance from receipts, fiscal year 1920-----	420,466.84
Cooperative work, Forest Service (contributions from private sources)-----	2,674,737.61
Receipts for fiscal year 1921 (see p. 60)-----	\$1,965,678.20
Balance from receipts, fiscal year 1920-----	709,059.41
Total available-----	3,567,229.70
Actual expenditures from special funds-----	2,488,979.49
Unexpended balance, June 30, 1921 (available for expenditure during fiscal year 1922)-----	1,078,250.21

The total expenditure of \$32,000,000 for the regular work of the department was allotted by types of activity approximately as follows: Research, \$9,000,000; extension, \$3,000,000; service, \$3,000,000; and regulatory work, \$17,000,000.

In this connection it should be pointed out that over one-half of the funds for service and regulatory work were expended in the performance of the primary functions of government rather than for the direct development of agriculture. Such functions as the administration and protection of the national forests, the weather service, enforcement of the food and drugs act and the meat-inspection law, as well as other similar service and law enforcement work, are not conducted in the interest of the producer, but administered for the benefit of all.

The department received during the fiscal year 1921 the following amounts, which were covered into the Treasury:

Receipts of Department of Agriculture, fiscal year 1921.

Weather Bureau: Receipts from United States telegraph lines	\$6,365.84
Forest Service: Sales of timber, grazing fees, and use of forest lands (exclusive of receipts used for construction of roads and trails for States)	2,032,909.97
Bureau of Chemistry:	
Examination of samples of flour, oleomargarine, etc	1,465.00
Sale of hearings	126.40
Bureau of Biological Survey: Sale of animal skins	9,734.85
Bureau of Soils: Sale of kelp, char, potash, and carbon	13,812.93
Division of Publications: Sale of maps, prints, lantern slides, and card indexes	1,897.35
States Relations Service: Sale of products grown at insular experiment stations	5,153.71
Bureau of Markets:	
Inspection of food products	97,352.00
Grain standard appeals	21,948.43
Warehouse disputes	2,847.00
Classifying cotton	144,530.80
Sale of cotton standards	16,351.40
Sale of loose cotton	16,630.93
Sale of grain	10,817.77
Federal Horticultural Board: Charges for fumigating cars and wagons	60,382.50
Various bureaus: Miscellaneous collections, including sale of condemned Government property	72,552.49
	2,514,879.37
Forest Service:	
Sale of timber, grazing fees, and use of forest lands (applicable to construction of roads and trails)	\$472,025.25
Contributions for cooperative work	1,965,678.20
	2,437,703.45
Total receipts, 1921	4,952,582.82

In addition to the \$32,000,000 expended by the department for the conduct of its investigative, regulatory, and other routine activities, appropriations amounting to \$269,513,180.34 were administered by the department, though no part of them was applied to the prosecution of its regular work. These funds were provided for the following purposes:

For extension work in agriculture and home economics (provided by the Smith-Lever Act of May 8, 1914, and paid direct to the States)-----	\$3,580,000.00
Supplementary Smith-Lever agricultural extension work (provided by the Agricultural appropriation act for 1921)-----	1,500,000.00
Federal aid road construction (provided by the acts of July 11, 1916, and Feb. 28, 1919, including balances from prior years)-----	¹ 259,703,180.34
Rural post roads----- \$251,154,318.39	
Roads and trails within or adjacent to national forests----- 8,548,861.95	
Farmers' seed-grain loans (made immediately available by the Agricultural appropriation act for the fiscal year 1922 for expenditure during 1921)-----	2,000,000.00
Payments from national forest receipts for the benefit of county schools and roads-----	1,285,000.00
Research work of State agricultural experiment stations provided by the Agricultural appropriation act for 1921 and paid direct to the States)-----	1,440,000.00
Study of short-time rural credits (provided by the Agricultural appropriation act for 1921 for use of a special congressional committee)-----	5,000.00
Total-----	269,513,180.34

The number of employees in the department on June 30, 1921, was 18,748, a decrease of 628 from June 30, 1920.

¹ \$62,535,342.54 of this amount was actually expended during the fiscal year 1921, leaving a balance of \$187,167,837.80 available for expenditure during the fiscal year 1922.

REVIEW OF AGRICULTURAL PRODUCTION AND EXPORTS.

Acreage of crops in the United States.

[Figures refer to planted acreage for winter wheat and rye.]

Crop.	1921 (preliminary estimate).	1920 (subject to revision). ¹	1919 (subject to revision).	1918	1917	1916	1915	1914	Annual average, 1910-1914.
CEREALS.									
Corn.....	108,901,000	104,601,000	100,072,000	104,467,000	116,730,000	105,296,000	106,197,000	103,435,000	105,240,000
Wheat.....	58,628,000	61,176,000	73,692,000	64,352,000	58,306,000	56,810,000	62,042,000	54,601,000	52,452,000
Oats.....	44,829,000	43,323,000	41,835,000	44,349,000	43,553,000	41,527,000	40,996,000	38,442,000	38,014,000
Barley.....	7,713,000	8,083,000	7,198,000	9,740,000	8,933,000	7,757,000	7,148,000	7,565,000	7,583,000
Rye.....	4,633,000	5,250,000	7,232,000	6,708,000	4,480,000	3,474,000	3,153,000	2,773,000	2,562,000
Buckwheat.....	691,000	729,000	739,000	1,027,000	924,000	828,000	769,000	792,000	826,000
Rice.....	864,000	1,337,000	1,091,800	1,118,550	980,900	869,000	803,000	694,000	733,000
Grain sorghums.....	5,159,000	5,404,000	5,031,000	6,036,000	5,153,000	3,944,000	4,153,000	.....	.....
Total.....	229,445,000	225,712,000	236,890,800	237,797,550	239,119,900	220,505,000	225,261,000	208,362,000	2,207,420,000
VEGETABLES.									
Potatoes.....	3,972,000	3,929,000	3,952,000	4,295,000	4,384,000	3,565,000	3,734,000	3,711,000	3,686,000
Sweet potatoes.....	1,186,000	1,085,000	1,042,000	940,000	919,000	774,000	731,000	603,000	611,000
Total.....	5,158,000	5,014,000	4,994,000	5,235,000	5,303,000	4,339,000	4,465,000	4,314,000	4,287,000
Tobacco.....	1,336,800	1,894,400	1,910,800	1,647,100	1,518,000	1,413,000	1,369,900	1,224,000	1,209,000
Cotton.....	26,519,000	35,578,000	33,566,000	36,008,000	33,841,000	34,985,000	31,412,000	36,832,000	35,350,000
Grand total.....	262,458,800	268,498,400	277,361,800	280,637,650	279,781,900	261,242,000	262,507,900	250,732,000	248,256,000

¹ Figures for 1920 are to be revised Dec. 12 and 15, 1921.² Excluding grain sorghums.

Crop production in the United States.

[The figures are in round thousands—i. e., 000 omitted.]

Crop.	1921 (unrevised estimate, November, 1921).	1920 (subject to revision).	1919 (subject to revision).	1918	1917	1916	1915	1914	Annual average, 1910-1914.
CEREALS.									
Corn.....	3,151,698	3,232,367	2,858,509	2,502,665	3,065,233	2,566,927	2,994,793	2,672,804	2,732,457
Wheat.....	740,655	787,128	934,265	921,438	636,655	636,318	1,025,801	891,017	728,225
Oats.....	1,078,519	1,526,655	1,231,754	1,538,124	1,592,740	1,251,837	1,549,030	1,141,060	1,157,961
Barley.....	163,399	202,024	161,345	256,225	211,759	182,309	228,851	194,953	186,208
Rye.....	64,332	69,318	88,909	91,041	62,933	48,862	54,050	42,779	37,568
Buckwheat.....	14,894	13,789	15,244	16,905	16,022	11,662	15,056	16,881	17,022
Rice.....	33,020	53,710	42,790	38,606	34,739	40,861	28,947	23,649	24,378
Grain sorghums.....	125,724	143,939	127,568	73,241	61,409	53,858	114,460	.....	.....
Total.....	5,372,241	6,028,330	5,460,384	5,438,245	5,681,490	4,792,634	6,010,988	14,983,143	14,883,819
VEGETABLES.									
Potatoes.....	356,076	428,368	365,773	411,860	442,108	286,953	359,721	409,921	360,772
Sweet potatoes.....	105,841	112,368	105,405	87,924	83,822	70,955	75,639	56,574	57,117
Beans (commercial).....	9,332	9,075	11,935	17,397	16,045	19,715	10,321	11,585	.....
Onions (commercial).....	12,833	23,525	11,398	19,336	12,376	8,562	7,664	(2)	.....
Cabbage (commercial).....	665	982	357	498	475	255	671	(2)	.....
FRUITS.									
Peaches.....	33,195	43,697	49,578	33,094	48,765	37,505	64,097	54,109	43,752
Pears.....	9,780	17,279	15,472	13,382	13,281	11,874	11,216	12,086	11,184
Apples.....	102,290	244,022	153,323	169,625	166,749	193,905	230,011	253,200	197,888
Cranberries (3 States).....	376	431	566	352	249	471	441	697	.....

¹ Excludes grain sorghums.² No estimate.

Crop production in the United States—Continued.

Crop.	1921 (unrevised estimate, November, 1921).	1920 subject to revision).	1919 (subject to revision).	1918	1917	1916	1915	1914	Annual average, 1910-1914.
MISCELLANEOUS.									
Flaxseed.....	8,509	10,990	7,661	13,369	9,164	14,296	14,030	13,749	18,353
Sugar beets.....	7,480	8,546	6,421	5,949	5,980	6,228	6,511	5,585	5,391
Tobacco.....	1,020,874	1,508,064	1,454,725	1,439,071	1,249,276	1,153,278	1,062,237	1,034,679	991,938
All hay.....	94,619	108,233	109,152	91,139	98,439	110,992	107,263	88,686	81,640
Cotton.....	6,537	13,440	11,421	12,041	11,302	11,450	11,192	16,135	14,259
Sorghum syrup.....	43,864	43,876	35,409	29,643	37,472	13,668	14,823	13,551	.....
Peanuts.....	33,664	35,960	33,925	46,010	52,505	34,434	.....	.....	.....
Broom corn (5 States).....	3 30	3 34	51	62	57	39	52	.....	.....
Clover seed.....	1,214	1,760	1,341	1,197	1,488	1,706	.....	.....	.....

³ 7 States.

Exports of domestic foodstuffs and cotton from the United States.

[Reports of Bureau of Foreign and Domestic Commerce, United States Department of Commerce.]

Article exported.	Year ending June 30—						Annual average, 1910-1914.
	1921	1920	1919	1918	1917	1916	
Amount.	Percent of 1910-1914.						
Wheat..... bushels..	293,267,637	515.3	122,430,724	178,582,673	34,118,853	149,831,427	173,274,015
Wheat flour..... barrels..	16,183,234	151.5	21,651,961	24,181,979	21,879,951	11,942,778	15,520,669
Oats..... bushels..	4,302,346	51.8	33,944,740	96,380,974	105,887,309	88,94,401	96,809,551
Rye..... do.....	45,735,052	5,350.6	37,463,285	27,510,188	11,990,123	13,260,015	14,322,457
Barley..... do.....	20,457,198	259.1	26,571,284	20,457,781	26,285,375	16,381,077	27,473,160
Corn..... do.....	66,911,093	168.1	14,467,926	16,687,538	40,997,827	64,720,842	38,217,012
Total, 5 cereals and flour, pounds..	28,195,776,780	334.5	16,859,428,924	21,996,905,576	13,951,418,808	19,330,110,628	20,750,577,136
Sugar..... do.....	582,698,488	821.0	1,444,080,665	1,115,865,161	576,483,050	1,248,908,286	1,630,150,863
Dairy products:							
Butter..... do.....	7,829,255	183.0	27,155,834	33,739,960	17,735,966	26,835,092	13,487,481
Cheese..... do.....	10,825,603	220.2	19,378,158	18,791,553	44,303,076	66,050,013	44,394,301
Milk (condensed)..... do.....	266,506,031	1,689.5	710,533,270	728,740,509	528,759,232	259,141,231	159,577,620
Total dairy products..... do.....	285,160,889	1,142.1	757,067,262	781,272,022	590,798,274	352,026,336	217,459,402
Meat and meat products:							
Canned beef..... do.....	10,785,306	114.8	31,133,918	108,459,660	97,313,283	67,536,125	50,863,765
Fresh beef..... do.....	21,084,203	71.6	153,500,647	332,205,176	370,032,900	197,177,101	231,214,000
Pickled beef..... do.....	23,312,856	70.9	32,383,501	45,065,641	54,467,910	58,053,667	38,114,682
Oleo oil..... do.....	106,414,800	38.0	74,529,494	59,292,122	56,603,388	67,110,111	102,645,914
Oleomargarine..... do.....	6,219,165	190.3	20,952,180	18,570,400	6,309,896	5,051,287	5,426,221

Exports of domestic foodstuffs and cotton from the United States—Continued.

Article exported.	Year ending June 30—					Annual average, 1910-1914.
	1921	1920	1919	1918	1917	
Meat and meat products—Continued.						
Stearin.....pounds...	19,177,311	592.9	22,505,602	11,537,284	10,360,030	11,457,907
Tallow.....do.....	16,843,868	58.1	32,937,026	16,172,111	5,014,964	13,234,533
Canned pork.....do.....	1,118,967	26.5	3,261,967	5,273,329	5,194,468	29,008,749
Fresh pork.....do.....	57,043,446	2,818.5	27,224,941	19,644,388	21,390,288	4,227,086
Bacon.....do.....	489,298,109	268.2	803,666,861	1,238,247,321	815,294,424	50,435,615
Hams and shoulders.....do.....	172,011,676	103.1	275,455,931	667,240,022	419,571,869	63,005,524
Pickled pork.....do.....	33,286,062	69.0	41,643,119	31,503,997	33,221,502	3,908,193
Lard.....do.....	746,157,356	157.3	587,224,549	724,771,382	444,769,540	182,471,092
Lard, neutral.....do.....	22,544,303	51.7	23,202,027	17,395,888	4,258,529	166,813,134
Lard compounds.....do.....	42,155,971	62.6	44,195,842	128,157,327	31,278,382	48,274,929
Sausage, canned.....do.....	4,129,723	69.5	7,034,150	8,503,580	5,787,108	474,354,914
Sausage, other.....do.....	4,926,552	.....	14,750,963	9,721,925	9,239,341	43,571,550
Sausage casings.....do.....	29,894,684	88.8	24,379,414	13,524,093	6,173,578	26,021,054
Total 18 meat products.....do.....	1,806,704,358	127.5	2,220,042,132	3,455,285,647	2,344,048,245	36,980,614
Total of food products mentioned above.....pounds...	30,870,340,515	310.5	21,280,568,983	27,349,328,406	22,932,105,016	3,827,475,389
Cotton.....do.....	2,811,445,550	63.6	3,543,743,487	2,762,946,754	2,320,511,665	4,403,578,499
Grand total.....do.....	33,681,786,065	234.5	24,824,312,470	30,112,275,160	19,783,269,012	4,419,802,157
						14,362,027,877

12-year average.

14-year average.

Estimated production of meat and wool.

[The figures are in round thousands, i. e., 000 omitted.]

Product.	1921	1920	1919	1918	1917	1916	1914	1909
Beef and veal ¹ ..lbs..	6,900,000	7,020,000	7,422,000	8,465,000	7,384,007	6,670,938	6,078,908	8,138,000
Pork and lard ¹ ..do..	10,600,000	10,406,000	11,388,000	11,248,000	8,450,148	10,587,765	8,768,532	8,199,000
Mutton and goat ¹.....lbs..	700,000	561,000	635,000	537,000	491,205	633,969	739,401	615,000
Total.....do..	18,200,000	17,987,000	19,445,000	20,250,000	16,325,360	17,892,672	15,586,841	16,952,000
Wool (including pulled wool)..lbs..	.....	302,207	313,638	298,870	281,892	288,490	290,192	289,420

¹ Estimated for 1914-1919 by the Bureau of Animal Industry. Figures for meat production for 1921 are tentative estimates based upon 1920 production and a comparison of slaughter under Federal inspection for 9 months of 1920 with the corresponding 9 months in 1919.

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REPORT OF THE CHIEF OF THE DIVISION OF ACCOUNTS AND DISBURSEMENTS.

UNITED STATES DEPARTMENT OF AGRICULTURE,
DIVISION OF ACCOUNTS AND DISBURSEMENTS,
Washington, D. C., October 8, 1921.

SIR: As requested in your letter of August 1, 1921, I am transmitting herewith the annual report of the Division of Accounts and Disbursements for the fiscal year ended June 30, 1921.

Respectfully,

A. ZAPPONE,
Chief of Division.

Hon. HENRY C. WALLACE,
Secretary of Agriculture.

CHARACTER OF THE WORK.

The Chief of the Division of Accounts and Disbursements, in accordance with law and regulation, pays accounts submitted by the various bureaus, divisions, and services of the department. Accounts are examined to ascertain that approvals are genuine, that extensions and additions are correct, and that there are appropriations out of which they are legally payable. A cashbook record is maintained of all individual payments, and ledger records are kept of disbursing and appropriation debits and credits of all funds of the department. Through the use of a card index duplicate payments are prevented and a ready reference to payments is available. The division also supervises the placing of funds to the official credit of temporary special disbursing agents and other fiscal officers of the department, and after making a record thereof transmits their accounts to the General Accounting Office. It receives and accounts for all moneys due the department from various sources; makes advances of public funds to employees for the payment of their expenses while traveling on official business; maintains a record of liabilities and disbursements in connection with purchases of lands under the Weeks forestry law; keeps the departmental record of amounts withheld from employees' salaries under the provisions of the retirement act of May 22, 1920, and, under the direction of the Secretary and the Budget Officer, compiles the annual estimates of appropriations. Miscellaneous financial reports are prepared from time to time as required.

WORK OF THE YEAR.

APPROPRIATIONS, EXPENDITURES, ETC.

To carry on the work of the Department of Agriculture during the fiscal year ended June 30, 1921, Congress appropriated \$31,712,784 in the agricultural act for that fiscal year, in addition to which permanent annual appropriations, special appropriations, deficiency appropriations, and the appropriation for printing and binding were available, amounting to \$113,079,000, making a total of \$144,791,784. During the year the disbursements of the department amounted to \$120,103,339.78, of which \$39,775,247.54 was disbursed from the regular annual and permanent annual appropriations made for the fiscal year 1921 and \$80,328,092.24 from indefinite appropriations and special funds and from balances of appropriations remaining from prior fiscal years. The unexpended balances of annual and permanent annual appropriations for the fiscal year amounted to \$105,016,536.46. Of this sum \$100,000,000 represents an amount appropriated for cooperative construction of rural post roads; \$1,000,000 cooperative construction of roads and trails, national forests; and \$2,434,298.82 Federal forest road construction, leaving an unexpended balance of \$1,582,237.64 chargeable to annual and permanent annual appropriations for 1921. A large part of this sum, however, is covered by outstanding liabilities. All of the \$100,000,000 appropriated for road construction has been allotted to the various States and will be paid out during the fiscal years 1922 and 1923 as fast as road work is completed by the States. The other amounts mentioned for roads and trails and for Federal forest road construction are available until expended. There are, however, some outstanding liabilities against these appropriations.

Supplemental accounts for the year 1920 were also paid, amounting to \$3,648,374.81.

On June 30, 1921, the unexpended balances for the year 1919, amounting to \$5,188,461.92, were finally covered into the Treasury to the "Surplus fund."

There were received, examined, and paid by this office 173,866 vouchers and pay rolls, which required the issuance of 316,391 checks on the Treasurer of the United States. There were also issued 68,952 checks against funds deposited in the disbursing clerk's special account with the Treasurer.

There were also sent to the Treasury Department for payment 9,308 accounts.

LOST CHECKS.

During the year 202 checks were lost in transit through the mails or by the payees, and were duplicated by this office.

PUBLIC MONEYS RECEIVED FROM VARIOUS SOURCES.

There were received from various sources and deposited in the Treasury to the credit of the proper funds the following sums:

Telegrams over Government lines.....	\$6,365.84
Payment by packers for overtime services of meat-inspection employees.....	224,987.09
Cost of distributing war materials to various States.....	125,709.98
Fumigation of cars and wagons.....	60,382.50
Cost of market inspection of food products.....	97,352.00
Cost of examination of samples of flour, oleomargarine, etc.....	1,465.00
Cost of grain standards appeals.....	21,948.43
Cost of warehouse disputes.....	2,847.00
Cost of classification and sale of cotton (revolving fund).....	144,580.80
Sale of maps, prints, and lantern slides.....	1,650.34
Sale of hearings.....	126.40
Sale of kelp char, potash, and carbon.....	13,812.93
Sale of animals and animal skins.....	9,734.85
Sale of card indexes.....	247.01
Sale of cotton standards.....	16,351.40
Sale of loose cotton.....	16,630.93
Sale of grain.....	10,817.77
Sale of miscellaneous Government property.....	72,552.49
Sale of agricultural products, insular experiment stations.....	5,153.71
Cooperative work, Forest Service.....	1,964,217.93
Forest reserve fund.....	1,776,760.03
Miscellaneous collections, refund on mileage books, etc.....	32,225.97
 Total.....	4,605,870.40

Statement of appropriations, disbursements, and unexpended balances for the United States Department of Agriculture.

[Fiscal years 1839 to 1904, inclusive.]

Fiscal year.	Amount ap- propriated.	Amount dis- bursed.	Amount unex- pended.	Fiscal year.	Amount ap- propriated.	Amount dis- bursed.	Amount unex- pended.
1839.....	\$1,000.00	\$1,000.00		1872.....	\$197,070.00	\$195,977.25	\$1,092.75
1840.....				1873.....	202,440.00	201,321.22	1,118.78
1841.....				1874.....	259,871.00	235,946.78	23,924.22
1842.....	1,000.00	1,000.00		1875.....	357,380.00	341,079.88	16,300.17
1843.....				1876.....	264,120.00	213,843.64	50,276.36
1844.....	2,000.00	2,000.00		1877.....	333,687.00	327,206.23	6,480.77
1845.....	2,000.00	2,000.00		1878.....	327,640.00	326,634.94	1,005.06
1846.....	3,000.00	3,000.00		1879.....	217,400.00	217,390.00	40.00
1847.....	3,009.00	3,000.00		1880.....	210,500.00	209,361.72	1,138.28
1848.....	4,500.00	4,500.00		1881.....	284,300.00	276,448.53	7,851.47
1849.....	3,500.00	3,500.00		1882.....	371,500.00	362,961.34	8,538.66
1850.....	5,500.00	5,500.00		1883.....	685,914.00	669,486.61	17,454.39
1851.....	5,500.00	5,500.00		1884.....	648,140.00	645,116.96	3,023.04
1852.....	5,000.00	5,000.00		1885.....	877,690.00	780,694.61	96,995.36
1853.....	5,030.00	5,000.00		1886.....	825,248.00	666,470.89	158,777.11
1854.....	10,050.00	10,000.00		1887.....	872,715.00	843,360.33	29,354.67
1855.....	50,000.00	50,000.00		1888.....	1,864,730.00	1,848,793.56	15,936.44
1856.....	30,000.00	30,000.00		1889.....	1,975,080.00	1,874,189.62	100,890.38
1857.....	75,000.00	75,000.00		1890.....	1,894,200.00	1,605,884.51	198,315.49
1858.....	63,500.00	63,157.25	\$342.75	1891.....	2,335,502.00	2,230,730.15	105,771.85
1859.....	60,030.00	60,000.00		1892.....	3,538,153.00	3,487,759.54	50,393.46
1860.....	40,000.00	40,000.00		1893.....	3,323,060.00	3,138,429.53	184,630.47
1861.....	60,000.00	60,000.00		1894.....	3,703,500.00	3,082,113.70	626,386.30
1862.....	64,000.00	63,704.21	295.79	1895.....	3,611,915.00	3,126,030.38	485,884.62
1863.....	80,000.00	80,000.00		1896.....	3,688,750.00	3,199,653.20	489,096.80
1864.....	119,770.00	109,270.00	10,500.00	1897.....	3,940,537.00	3,840,286.45	100,250.55
1865.....	150,604.00	150,496.50	107.50	1898.....	3,572,902.00	3,530,510.44	42,391.56
1866.....	167,787.82	167,787.82		1899.....	3,987,202.00	3,958,212.73	28,989.27
1867.....	199,100.00	199,100.00		1900.....	4,127,922.00	4,069,503.42	58,418.58
1868.....	279,020.00	277,094.34	1,925.66	1901.....	4,423,500.00	4,358,371.42	65,128.58
1869.....	210,198.00	210,198.00		1902.....	5,090,433.00	5,070,328.28	20,104.72
1870.....	156,440.00	151,595.93	4,843.07	1903.....	6,206,960.00	5,925,344.84	281,615.16
1871.....	188,180.00	186,876.81	1,303.19	1904.....	6,740,024.00	6,684,311.63	55,712.37

Statement of appropriations, disbursements, and unexpended balances for the United States Department of Agriculture.

Fiscal year.	Agricultural appropriation act.		Other acts.			Total.		
	Appropriated.	Disbursed.	Unexpended.	Disbursed.	Unexpended.	Appropriated.	Disbursed.	Unexpended.
1905.....	\$5,902,040.00	\$5,826,365.63	\$75,671.37	\$687,500.00	\$6,385,000.00	\$6,589,540.00	\$6,513,865.63	\$75,674.37
1906.....	6,882,690.00	6,688,510.02	1,196,179.98	1,488,000.00	1,317,407.08	8,376,000.00	8,175,510.02	1,196,179.98
1907.....	9,382,910.00	9,358,815.02	364,031.96	1,189,500.00	8630,002.32	11,110,440.00	9,916,252.70	1,200,187.30
1908.....	9,162,200.00	9,162,200.00	9,162,200.00	3,167,784.27	273,965.73	13,613,010.00	13,417,739.63	442,300.37
1909.....	11,672,106.00	11,478,666.40	193,439.60	4,391,000.00	4,278,100.05	11,033,106.95	15,756,766.45	306,339.55
1910.....	12,995,639.00	12,617,918.27	347,117.73	4,141,700.00	4,077,877.86	63,822.14	17,136,756.00	410,939.87
1911.....	13,457,636.00	13,184,652.22	7,345,600.00	7,181,362.42	160,697.58	20,832,636.00	20,308,954.64	403,681.36
1912.....	16,900,016.00	15,530,970.53	1,369,016.45	5,503,193.00	5,455,236.73	47,456.27	22,403,209.00	20,938,207.28
1913.....	16,631,195.00	16,005,418.40	616,017.60	6,010,819.00	5,966,178.82	44,310.18	22,662,315.00	21,971,927.22
1914.....	17,985,945.00	17,202,610.79	721,331.21	6,109,000.00	6,085,710.21	14,289.79	24,086,945.00	23,318,321.00
1915.....	19,865,832.00	19,112,219.69	753,582.31	9,011,233.00	9,001,614.19	12,628,81	23,880,075.00	23,363,88
1916.....	22,971,782.00	22,561,771.12	410,010.88	5,032,300.00	5,032,297.20	2,80	28,001,082.00	27,591,068.32
1917.....	24,918,852.00	23,178,008.83	1,770,812.17	11,184,248.00	11,182,171.73	2,076.27	36,133,100.00	34,360,180.56
1918.....	25,929,113.00	23,529,897.57	2,399,215.43	45,201,400.00	42,439,706.50	2,761,683.50	71,130,513.00	65,986,604.07
1919.....	27,875,353.00	21,733,088.27	3,122,264.73	88,211,863.00	81,184,579.91	2,027,283.00	11,1,087,216.00	10,837,668.18
1920.....	33,899,761.00	30,226,636.16	3,673,124.84	108,828,163.00	40,938,828.48	68,795,924.00	72,265,464.64	72,468,459.36
1921.....	31,712,781.00	30,527,558.51	1,183,223.46	113,073,000.00	9,217,689.00	103,831,311.00	144,791,784.00	105,016,536.46

¹ As all appropriations remain available for three years for paying outstanding liabilities, the figures shown for expenditures and balances are subject to correction.

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REPORT OF THE CHIEF OF THE BUREAU OF ANIMAL INDUSTRY.

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
Washington, D. C., October 12, 1921.

SIR: I have the honor to transmit herewith a report of the operations of the Bureau of Animal Industry for the fiscal year ended June 30, 1921.

Respectfully,

J. R. MOHLER,
Chief of Bureau.

Hon. HENRY C. WALLACE,
Secretary of Agriculture.

ACTIVITIES OF NOTEWORTHY INTEREST.

TUBERCULOSIS ERADICATION MAKES PROGRESS.

Prominent among the bureau's activities in suppressing animal diseases has been the rapid progress of tuberculosis eradication. Under the accredited-herd plan, by which cattle owners voluntarily place their herds under Federal and State supervision, the results are obtained systematically and effectively. Besides, they bring about close and friendly relations between the live-stock owners and the bureau. This spirit promises to be helpful in the other lines of disease-control work. Already there is a noticeable growth of sentiment favoring better methods of sanitation on live-stock farms.

More than 75,000 herds are under supervision for the eradication of tuberculosis, a factor that is having wide influence in other disease-control work, for each owner who is cleaning his herd from tuberculosis generally gains valuable experience in the principles of disease transmission and hygiene. The personal contact between bureau veterinarians and stock owners has an educational effect in the community.

In most States applications for testing have been more numerous than could be handled at once, and at the end of the fiscal year 14,000 herds were on the waiting list to be tested.

ACCREDITED HERDS DOUBLE DURING YEAR.

The number of herds officially accredited as free from tuberculosis at the end of the year was 8,201, more than twice the number at the same time the preceding year. Herds tested once without showing any reactors numbered 49,814, which is approximately three times as many as the year before.

INCREASE IN DISEASE-FREE AREAS.

Progress in area work, which means the testing of all cattle within a definite area—usually a county—likewise has been rapid. On June 30, 1921, 10 entire counties had completed one or more official tests of all their cattle and 49 others had entered upon active area campaigns. These figures represent striking gains over the year before.

Popular interest regarding tuberculosis-free areas has reached the point where live-stock owners in such areas are demanding protection against the possibility of reinfection. Local public opinion doubtless has a restraining influence on persons who might seek to introduce animals of doubtful health. But the establishment of a permanent and substantial safeguard unquestionably would result in a rapid extension of area testing. Efforts are being made to work out this problem in cooperation with State officials and the industry.

TUBERCULOSIS IS MOST DANGEROUS CATTLE DISEASE.

In spite of the excellent progress being made against tuberculosis, this disease is still the most serious live-stock scourge in the United States to-day. Meat-inspection records furnish facts on the prevalence of animal diseases that are of vital importance to every stockman. Practically three-fourths of all cattle carcasses and half of all those of swine failing to pass Federal inspection last year were condemned on account of tuberculosis. Unrelenting efforts are being made to impress on live-stock owners the menace of tuberculosis to their stock and to human beings.

HOG CHOLERA SHOWS DECREASE.

Hog cholera, though controllable with certainty by the preventive serum treatment, continues to take a heavy toll from growers who fail to guard against the disease. Deaths of hogs from cholera numbered 39.3 per thousand, which was slightly less than in the preceding year. Bureau veterinarians trained in hog-cholera control work investigated reports of outbreaks, made autopsies, and took necessary measures to stamp out centers of infection. During the year these veterinarians demonstrated methods of cleaning and disinfection on 656 premises following hog-cholera outbreaks.

In the light of present technical and field knowledge the complete eradication of hog cholera from the United States is a remote possibility. But swine growers may reduce their losses to a negligible amount by precautionary measures and by the preventive-serum treatment. These subjects are fully discussed in available printed matter issued by the department.

CATTLE TICK LOSES GROUND IN SIX STATES.

Efforts to eradicate the cattle-fever tick of the South resulted during the year in the release of 32,171 square miles from quarantine. This gain in tick-free area was possible through cooperation with the bureau by State and local officials and live-stock owners. The territory released from the domain of the tick was in six States: Alabama, Georgia, Louisiana, North Carolina, Oklahoma, and Texas.

During the year it was necessary, however, to re-quarantine a number of areas. Previously these areas had been so well freed of ticks as to be released from Federal quarantine under satisfactory representation by local authorities that they would complete the work. To overcome such setbacks is not so great an undertaking as new work, however. The dipping vats are at hand and the people understand the procedure.

The complete eradication of cattle ticks from the country has been somewhat delayed by local tendencies to force tick eradication into unfortunate alliances with various political issues. The regions which have banished the tick quickly and completely regarded it as an economic drawback. They acted to remove that drawback and did so. Fortunately the benefits which tick-free areas enjoy are gradually coming closer to the areas still infested and under quarantine. Such an influence in time must have an irresistible effect in bringing about the complete extermination of cattle ticks.

FOREIGN LIVE-STOCK DISEASES EXCLUDED.

Precautions to exclude live-stock diseases from abroad were completely successful during the year. Foot-and-mouth disease in western Europe and rinderpest in the Philippines are among the most imminent dangers to our live stock. But through scrupulous care in the enforcement of quarantine measures, supplemented by the vigilance of bureau inspectors stationed at important live-stock centers in this country, no outbreaks of foreign diseases occurred.

IMPROVEMENT OF DOMESTIC ANIMALS.

Pressure of economic circumstances aided greatly during the year in quickening national interest in improved live stock. A general decline in market prices from war-time levels compelled attention to economy of production and to a more frequent turnover on investment. In both of these respects purebred and grade animals excel those of nondescript breeding.

Figures from the 1920 census, for the first time in history, give dependable information concerning purebred live stock on farms in the United States. They show that of all farms reporting domestic animals, less than one in nine has any purebred live stock. The per cent of purebred animals to the total is naturally smaller. In cattle the purebreds are 3 per cent of the total; swine, 3.5 per cent; sheep, 1.3 per cent; and horses 0.6 per cent. It is noteworthy that in the Eastern States, especially in New England, which depends to a large extent on purchased feed for its stock, the proportion of purebreds in all classes is higher than in most other groups of States.

The bureau's efforts to bring about improvement in the quality and efficiency of average live stock have been well received. At the end of the year cow-testing associations, whose purpose is to improve dairy stock, numbered 452, containing 193,928 cows. The average production of these cows is nearly 50 per cent higher than for the country as a whole.

A parallel activity to cow-testing work is the organization of bull associations, which make possible the cooperative ownership and use of high-class bulls. On June 30, 1921, bull associations numbered 158, comprising a membership of 5,064 persons, who owned collectively

672 bulls of high quality. The popularity of bull associations is evidenced by an increase of 28 during the year.

The bureau's educational work for "Better Sires—Better Stock" continues to meet with gratifying response. Within the year 2,212 persons placed their live-stock raising on a purebred-sire basis. Added to the results of the preceding year, this makes a total of 4,290 persons who have filed with the department written declarations that they will use good, purebred sires for grading up all classes of live stock kept, including poultry. These persons own altogether more than 537,000 head of animals kept for breeding purposes.

Statistical facts derived from the better-sires movement show that the use of purebred sires brings about steady improvement in the quality of female stock and causes a reduction of scrub females to a negligible number on farms where purebred sires are used.

PROGRESS IN EXPERIMENTAL BREEDING.

Experimental breeding work at the various bureau stations has resulted in many interesting types, some of which promise to have distinct utility value. During the year progress in developing a new general-purpose fowl laying a white-shelled egg reached the point where the bureau was able to announce it as a new breed. No other general-purpose fowls lay white-shelled eggs. The new breed received the name "Lamona" in recognition of Harry M. Lamon, its originator. Color of shell influences prices for eggs at various important markets, and the Lamona breed is a distinct contribution to the poultry industry. The work is being continued so that creditable fowls of the Lamona breed may be produced in sufficient number for distribution to experiment stations.

At the United States sheep experiment station, near Dubois, Idaho, the Columbia sheep, reported last year as a new breed, have proved to be well adapted for range conditions. The Columbias are noticeably robust and the lambs are well developed at weaning time, a desirable point in sheep management on the range. In comparative tests with other breeds and types kept at the station, the Columbias yielded the most wool and mutton, but the Corriedales produced wool of apparently better quality. The results of manufacturing tests will establish more definitely the comparative excellence of the two wools.

The crossing of Columbia ewes with Corriedale bucks is now being undertaken with a view of combining the best qualities of both breeds.

The new type of American utility horse which the bureau is developing at Buffalo, Wyo., in cooperation with the State of Wyoming, continues to show improvement. Demand for stallions during the year was greater than could be supplied.

Progress in breeding Morgan horses at the United States Morgan horse farm likewise has been noteworthy. The bureau was fortunate in obtaining two valuable mares to add to its stud. The young stock produced at the farm during the year has been of good type and quality.

SOFT-PORK INVESTIGATIONS CONTINUED.■

Inquiry into the problem of "soft pork" begun last year has been continued systematically along several lines made necessary by developments in the work. The following swine feeds are receiving particular study: Peanuts, peanut meal, soy beans, rice by-products,

and mast. Altogether 416 swine were slaughtered and the pork studied during the year in connection with these investigations. Shrinkage of the meats is an important factor and has received special attention. The experiments have yielded a large quantity of significant, but as yet inconclusive, data.

DEVELOPMENTS IN COMMERCIAL DAIRYING.

Among dairy activities of the bureau, the development of creameries and cheese factories in the South is worthy of comment. These dairy manufacturing establishments are in many cases the fruits of previous extension work. Butter production in Mississippi and Tennessee has increased approximately 50 per cent within the year. Tennessee now has 10 cooperative cheese factories, the output of which has shown an increase of more than a fifth compared with a year ago.

Twenty-one cheese factories are in operation in North Carolina and a new factory was established in Georgia. There is a growing interest in dairying, and tangible evidence of this agricultural trend in the South is shown by improvement in cattle and construction of silos.

At the Grove City Creamery, Grove City, Pa., the Dairy Division of the bureau has continued its experiments in improved methods for making various dairy products. The manufacture of foreign types of cheese and also club cheese—half Roquefort and half Cheddar—received noteworthy attention during the year. There is increasing evidence to show that the United States need not be dependent on foreign countries for these classes of dairy products.

ECONOMIC VALUE OF MEAT-INSPECTION DATA.

The Federal meat-inspection service, in addition to its primary functions of insuring wholesome meat, furnishes useful live-stock statistics. About two-thirds of all meat animals slaughtered annually are Federally inspected, a proportion that is sufficiently large to form a good statistical basis. The system of making monthly compilations acts as a splendid current index to trends in the meat industry. A decline of 4.7 per cent from the previous year in the total of animals slaughtered under inspection corroborates other data pointing to a decline in public demand for meat.

The bureau compiles each year statistical tables, together with appropriate comments, showing production, consumption, imports, and exports of meats. The figures include the various principal classes of meats, both federally inspected and otherwise. This information has been well received by the live-stock industry and the meat trade.

NEED FOR LONG EXPERIMENTS—AND THEIR VALUE.

A wide range of experimental work was conducted during the year. Many of the projects are of long duration and so complex as not to lend themselves well for discussion among brief comments on progress. Yet these lines of continuous and persistent work conducted by untiring investigators are of great value to the industry. The experiments in contagious abortion are typical of this class of work. Short-time investigations of chronic diseases are almost valueless, because victims of the disease may become and for a long time remain danger-

ous carriers of the infection. The investigation of plants poisonous to live stock is another instance of work requiring many years of study before dependable conclusions can be drawn. A large proportion of the bureau's activities, in fact, is of such a kind. Though of slight popular interest at intermediate stages, accumulation of data ultimately takes the form of results that have a wide practical and valuable application.

INCREASED EFFICIENCY.

Several unusual difficulties have beset the bureau's path during the year. It is a stubborn fact that charges for transportation and subsistence were never higher than they have been during the fiscal year of 1921. It is a further fact that never before were there more calls for travel in the extending campaigns for the control and eradication of animal diseases—scabies, dourine, Texas fever, hog cholera, and tuberculosis. Added to this enlarged expense has been an increased expenditure for salaries. An enlightened policy of giving a living wage to the loyal employees of the department has resulted in placing the salaries of many lay inspectors, veterinarians, and other scientists at a figure more nearly commensurate with the worth of their services and more nearly in accord with the salaries paid outside the Government. Again, the prices for supplies, for printed forms, for chemicals and apparatus used in laboratories, for rent of scores of offices throughout the country, and for the many miscellaneous items necessary, are still at a high level.

Notwithstanding these increased charges, which ordinarily would indicate an increased number of employees, it is somewhat remarkable that the personnel has remained at a comparatively constant figure. Thus in 1916 there were 4,013 employees. During the war this number was necessarily increased, but by June 30, 1921, it had fallen to 4,137, practically normal.

It is a fair inference that this result has been brought about by the increased efficiency of employees, better paid and better satisfied, and also by the increasing use the bureau has been able to make of the services of its trained veterinarians. As the different eradication measures have developed, the bureau has to a greater and greater degree linked them together and combined them with the meat-inspection service. It is now a common practice to place all the disease-eradication work of a State or district under the control of one inspector in charge, who diverts his men from one project to another as circumstances may demand, charging the time consumed and the travel performed to the proper appropriation. In addition the practice is prevailing to a constantly increasing degree of shifting veterinarians from meat inspection to field work at the opening of the field season in the spring. Fortunately this is possible, as the great demand for meat inspection comes during the winter, when, because of weather conditions, the field service is curtailed. In these shifts the bureau makes every effort to change from station to station the younger and unattached members of the forces. The result has been the development of a large body of veterinarians who are capable of meeting all the demands made by the various forms of activity. Another important result has been the economy and efficiency of avoiding surpluses or idle forces when work falls off and insuring that there shall be no duplication of inspectors traversing a given territory.

PERSONNEL.

On May 1, 1921, on account of the retirement of Dr. A. M. Farrington from the bureau's service, the Miscellaneous Division was abolished, and partly in its stead there was formed the Office of Personnel, to which the work relating to the personnel of the bureau and the correspondence regarding veterinary education was assigned.

At the beginning of the fiscal year the bureau employees numbered 4,285. During the year 651 additions were made to bureau forces, 517 by appointment, 19 by transfer from other branches of the Government service, and 115 reinstatements of former bureau employees. During the same period 799 employees were separated from the service, 442 by resignation, 17 on account of death, 30 by transfer to other bureaus or departments, 4 were removed for cause, and all other separations numbered 306. At the end of the fiscal year the bureau personnel numbered 4,137, a net decrease of 148 during the year.

VETERINARY EDUCATION.

The number of accredited veterinary colleges, the graduates from which are allowed to take the civil-service examination for positions in the bureau, is 16, as in the preceding year. Of this number 11 are State colleges with veterinary departments, 3 are private veterinary colleges, and 2 are agricultural colleges which have become fully accredited, having raised their veterinary courses of study from two to four years. The graduates of two agricultural colleges with two-year veterinary courses are given credit for this course when entering one of the accredited veterinary colleges. Ten foreign veterinary colleges are now on the accredited list. During the year the Royal College of Veterinary Science and Agriculture, Copenhagen, Denmark, was given the accredited status.

The total number of freshmen enrolled in all veterinary colleges for the session beginning in the fall of 1920 was 182, as compared with 352 for the preceding year. The total enrollment at all veterinary colleges was 965, against 1,265 for the preceding school year. The number of graduates was 277, compared with 371 in 1920. Ten students were enrolled at the accredited agricultural colleges, all of whom were in the freshman and sophomore classes. The decline of 170, or nearly 50 per cent, in the number of freshmen enrolled during the year seems to indicate that the increased educational requirement has been one of the several factors accounting for the decreased number of applicants for matriculation, but with the compensation that the additional mental equipment required for entering students can not fail to insure a higher professional standing for the graduates.

LITERATURE, EXHIBITS, AND MOTION PICTURES.

New publications contributed by the bureau during the year numbered 88, including 24 Farmers' Bulletins, 18 Department Bulletins, 5 contributions to the Department Yearbook, 13 issues of Service and Regulatory Announcements (including index), 7 articles for the Journal of Agricultural Research, 7 Department Circulars, 3 miscellaneous pamphlets, 11 orders in the nature of regulations, and 4 posters. Other manuscripts written in the bureau and transmitted for outside publication numbered 78. In addition 196 news items were written for the Press Service to be given general publicity.

During the year the bureau contributed exhibits for numerous agricultural expositions, fairs, and shows. In this work plans and material originate in the various divisions and are coordinated by a bureau expert. They are then developed in cooperation with the department's central office of exhibits. The large field organization of the bureau has made it possible in many cases to detail local men to discuss exhibits shown in their territory.

Motion pictures relating to the bureau's work are proving to be valuable in presenting numerous projects to the public. During the year a two-reel film dealing with tuberculosis eradication was shown with unusual success. Other recent films include the subjects of meat inspection and better sires. The bureau selects and outlines the general message to be presented, and the department's office of motion pictures carries the plans to completion and makes the films. This method of handling the work has given admirable results.

RECOMMENDATIONS.

Among the specific needs of the live-stock industry one of the most pressing is a more adequate provision for indemnities in tuberculosis-eradication work. As pointed out, tuberculosis takes an enormous toll of loss among cattle and swine. More than that, being communicable to man, it is a menace to human beings. Increased funds for Federal indemnities will greatly hasten the eradication of the disease. States are making liberal expenditures, and, since the work is conducted jointly, progress is retarded when the Federal aid lags behind amounts which the States have appropriated.

Provision also should be made for the continuance of experimental work that was authorized and undertaken with a knowledge that completion would be a matter of several years, sometimes many years. To appropriate funds enough merely to start important experiments, and then so limit later funds as to hamper or stop the work, is both discouraging to the investigators and wasteful of public money. It is recommended that projects originally authorized be supported to conclusion, especially when definite results are in view. Some very promising experiments on contagious abortion had to be given up last year owing to lack of funds for continuing the work.

A small item is recommended to cover the educational campaign for "Better Sires—Better Stock," which continues to be successful and popular. Quality in live stock has an important bearing on international trade both in live animals and meat products. Foreign countries are paying great attention to this question, and the start which the department has made is deserving of support.

REPORTS BY DIVISIONS.

The year's work as conducted by the various divisions of the bureau is presented more fully in the following pages.

ANIMAL HUSBANDRY DIVISION.

The work of the Animal Husbandry Division, under George M. Rommel, chief, has undergone further reorganization in conformity with legislation by Congress. Two projects of importance, begun in 1912, were discontinued, namely, the work in military horse breeding and the extension work in animal and poultry husbandry. Neither

project, however, has been lost to the country. The work in military horse breeding has been transferred to the War Department, and in nearly all cases the extension specialists formerly on the department rolls have been taken over by State extension divisions. The department has thus had an active participation in pioneer work of importance in these lines and has had an important share in developing the plans and policies for the conduct of such work. The first stallions which stood for public service expressly to produce horses suitable for the mounted service of the United States Army were selected, placed, and handled by the Bureau of Animal Industry in cooperation with the War Department, several of them being still in service with the Army. The first specialist employed to devote his entire time to animal-club organization was an officer of this bureau. The great work now under way along these lines grew out of those small beginnings. The activities of the Animal Husbandry Division in the future will be devoted almost exclusively to research work in animal and poultry husbandry, a field of sufficient importance and magnitude to call for the best efforts, thought, and energy of which its officers are capable.

BEEF-CATTLE INVESTIGATIONS.

Beef-cattle experimental work has been continued in Arkansas, Kansas, Mississippi, and West Virginia, in cooperation with the State agricultural experiment stations. Investigations of the methods and cost of producing and fattening beef cattle have been continued in the Corn Belt and on the range.

MAINTAINING BEEF-BREEDING HERDS.

At the Coastal Plain Experiment Station, McNeill, Miss., 50 head of grade and native cows are being carried from April to November on 500 acres of cut-over land. They made satisfactory gains until June, when the woods grasses began to get tough. By drenching the cows and calves at intervals of 28 days with a 1 per cent solution of copper sulphate and snuff, losses from internal parasites were checked. From November 10 to November 27, 1920, the herd ran on stalk and velvet-bean pasture. It was then carried to March 24 (117 days) on a daily ration of 4 pounds of cottonseed meal and 10 pounds of native hay per 1,000 pounds live weight, without a loss in weight.

At Jonesboro, Ark., 30 head of purebred beef cows are being carried from April to November on approximately 100 acres of lespedeza pasture. During the 140-day winter feeding period they were maintained on approximately 22 pounds of silage, 8 of straw, 2 of hay, 2 of protein meal, and 1 of grain.

Separate records were kept to determine the feed requirements for maintaining herd bulls, growing yearling heifers and stocker steers, and feeding spring and fall calves. Experiments are being carried on to determine the most satisfactory winter ration for the breeding cows and whether or not it pays to feed calves grain while they are sucking their dams on pasture.

WINTERING AND FATTENING STEERS.

In continuation of the three-year experimental project begun in December, 1919, at Lewisburg, W. Va., to determine the best ration for wintering steers and the effects of the several rations on the gains

made by the steers when fattened subsequently on grass, the second year's work was begun December 28, 1920, with 60 steers averaging 984 pounds. These were divided into 6 lots of 10 steers each; each lot was wintered on a different ration, then all were put on good blue-grass pasture for summer fattening. The results will be reported at the conclusion of the project.

At McNeill, Miss., 36 steers were divided into 3 lots and fed 84 days to compare the following rations: (1) Silage, dry velvet beans, and cottonseed meal; (2) silage and dry velvet beans; (3) silage and soaked velvet beans. The last ration gave the best results, while the first ration was more satisfactory than the second.

BREEDING FOR MILKING QUALITY IN BEEF CATTLE.

The 20-year experiment begun September 1, 1915, at Manhattan, Kans., in cooperation with the Kansas Agricultural College, is being continued. Progress has been made in increasing the number of cows in the herd whose dams are of strictly beef type and have records of heavy milk production. Several heifers of the desired type from such dams are now in the herd and are to be tested during the coming year to determine whether or not they have inherited heavy milking qualities.

BEEF PRODUCTION IN THE CORN BELT.

The investigations in the Corn Belt States have been largely a continuation of the work in cooperation with the Office of Farm Management and Farm Economics of the department and with State experiment stations to determine the basic requirements for feed, labor, and miscellaneous items in fattening beef cattle. During the summer of 1920 approximately 500 complete farm business records were taken in Iowa, Illinois, Indiana, Nebraska, and Missouri, on farms where cattle feeding was one of the main enterprises. These records involved the fattening of 21,250 head of beef cattle during the winter of 1919-20. The records for 34,934 steers fed during the winters of 1918-19 and 1919-20 show the following average figures: Initial weight, 786 pounds; final weight, 1,070 pounds; gain, 284 pounds; feeding period, 174 days; feed consumed per 100 pounds of gain, 680 pounds grain, 62 pounds commercial concentrates, 391 pounds dry roughage, 863 pounds silage; 20 days on pasture.

In addition to the cooperative work which deals entirely with the fattening of beef cattle in the dry lot, some investigational work has been begun in the southwestern part of Wisconsin to determine the cost and quantities of feed required to fatten cattle on grass, with and without a supplement, and of feed required to keep the breeding herd of beef cattle for one year and to raise calves from weaning time to yearlings.

BEEF PRODUCTION ON THE RANGE.

An extensive field survey of beef-cattle production was made in the 17 western range States. A study was made of the most widely practiced methods of management of range cattle and of the problems that confront cattle producers in the Western States. Feed production and utilization were considered only so far as they related to beef-cattle production.

SWINE INVESTIGATIONS.

The herd of hogs kept at the bureau's experiment farm at Beltsville, Md., for breeding and feeding experiments averaged 424 head and comprised animals of the Duroc-Jersey, Hampshire, Tamworth, Chester White, Poland China, and Berkshire breeds.

Two exhibits of cured meats were prepared and were shown at fairs in 12 States. Meat cutting and curing demonstrations were held at Beltsville and at many points throughout the country, in cooperation with the States Relations Service of the department. At the National Swine Show an exhibit of hog-lot equipment was displayed.

E. Z. Russell, in charge of swine investigations, made a six months' trip to South America during the last half of 1920, in company with L. B. Burk, of the Bureau of Markets, visiting Brazil, Uruguay, Argentina, and Chile, for the purpose of studying live-stock conditions in those countries and the possibilities of United States breeders' selling breeding animals there. A report of this trip was published in the *Weekly News Letter* and given to the agricultural press.

FEEDING EXPERIMENTS.

Barley.—Among the tests conducted at Beltsville was one in cooperation with the Bureau of Markets in which different lots of hogs were fed for 68 days on heavy barley (49.2 pounds per bushel), stained barley (44.8 pounds per bushel), and light barley (41.3 pounds per bushel), to determine the relative values of these grades as feed for hogs. A check lot was fed on ground corn. All lots received a ration of 9 parts of grain and 1 part of fish meal by weight. Further tests are contemplated before drawing conclusions. The first test indicates, however, that barley is a less satisfactory feed than corn meal for fattening hogs, and that the rapidity and economy of gains from barley depend on its quality.

Fishery by-products.—The experiments in the use of fish meal and other fish-factory by-products were continued, in cooperation with the Bureau of Fisheries of the Department of Commerce and the Bureau of Chemistry of this department. Tests were made of shark meal, shrimp bran, red-snapper cannery waste, fish-glue-factory waste, specially prepared menhaden fish meals, fish meal preserved with a spruce-wood by-product (New Jersey fish meal), sardine-cannery waste, and whale-meat meal. These meals showed a protein content varying from 40 per cent in glue-factory meal to 75 per cent in whale meal. The results of a series of tests by the self-feeding method, combining corn with each of the fish meals and also with tankage for comparison, indicate that the fish products approximate very closely high-grade tankage in feeding value for hogs. The meat prepared from hogs fed in this way, both in its fresh state and after curing, was tried by many persons, who were asked to report on its quality and flavor. In no instance was any undesirable flavor or odor detected.

A feeding trial was also made in which fish meal and corn were hand-fed so as to permit the introduction of large amounts of fish meal into the ration, in order to determine whether or not an amount of fish meal could be consumed which would influence the flavor and quality of the meat. One lot of pigs was fed corn meal with 7½ per cent of fish meal added; a second lot, corn meal with 15 per cent of

fish meal; a third lot, corn meal with 22½ per cent fish meal; and a fourth lot with corn meal and 30 per cent of fish meal. Reports from tests of fresh meat, loin, and sausage were received from several of the best hotels in Washington and from the Home Economics Office of the States Relations Service to the effect that samples from each lot were entirely free from any trace of flavor or odor which was not normal for fresh pork products and that no evidence of fishy flavor or odor could be detected.

SOFT-PORK INVESTIGATIONS.

Studies of the soft-pork problem have been continued on a broader basis. The work of the past year combined with other information indicates that soft pork is produced under certain conditions in other sections of the country than the Southern States. Experiments were carried on in cooperation with the agricultural experiment stations of Alabama, Georgia, Indiana, Kentucky, Mississippi, North Carolina, and South Carolina, also on a farm near Calhoun City, Miss., as well as on the Government farms at Beltsville, Md., and Jeanerette, La. The feeds used were peanuts, peanut meal, soy beans, rice by-products, and mast. Four hundred and sixteen hogs were fed and slaughtered and the meat graded and tested. All the slaughtering was done at the Beltsville farm.

Samples of fat were subjected to chemical examination for determination of melting point, iodin number, and refractive index. The relationship between the carcass grading and the chemical determination has been found to be close in most instances. Study has also been made of the chemical structure of the fats of selected hogs.

While it is felt that material progress has been made toward a solution of the soft-pork problem, the work has not reached a point justifying definite conclusions.

SWINE HUSBANDRY EXTENSION.

Extension work in swine production was carried on in Oregon, Texas, Nebraska, Mississippi, Louisiana, North Carolina, and Indiana. The activities of the field agents were along the lines of stock judging, promoting club organizations, conducting demonstrations in meat curing and cutting, and advising with regard to selecting and feeding animals for shows. The seven agents conducted 148 demonstrations with a total attendance of 10,544, gave 329 lectures to audiences aggregating 21,606 persons, visited 727 farms, and placed 44 boars and 32 sows for breeding purposes. This work was discontinued by the department at the close of the fiscal year.

SHEEP AND GOAT INVESTIGATIONS.

FARM SHEEP INVESTIGATIONS.

Investigations in farm sheep husbandry were continued at the bureau's stations at Beltsville, Md., and Middlebury, Vt. Purebred animals have been kept at Beltsville, the flock consisting of Southdowns, Shropshires, Corriedales, and Hampshires, and numbering 216 at the close of the fiscal year, while the Middlebury work has been conducted with western ewes mated with Down rams, the flock comprising 318 animals.

Experiments to test the relation of nutrition of ewes at breeding time ("flushing") to the size of the lamb crop were continued at both farms. At Beltsville the ewes given extra pasture at breeding time produced 147 per cent of lambs, those fed grain produced 150 per cent, and those held on short pasture produced 126 per cent. A test to determine the effect of placing ewes on short feed after service indicated that change of treatment to either more or less feed is detrimental to "settling" the ewes. The flushing experiment at Middlebury resulted in 159 per cent of lambs for the unflushed lot and 137 per cent for the flushed lot. Change in pasture conditions following heavy fall rains practically resulted in the flushing of both lots.

The sale of the lambs born in 1920 shows it to be more profitable in Vermont to raise lambs dropped in May and June to be marketed in November than to have them dropped in February and March and marketed in July.

At the Coastal Plain Experiment Station, McNeill, Miss., native ewes are being crossed with Shropshire and Rambouillet rams for improvement in mutton quality and in weight and quality of fleece. The flock consists of 43 ewes, 8 wethers, and 30 lambs. First-cross lambs, both Shropshire and Rambouillet, show a marked improvement in conformation and in weight and quality of fleece.

RANGE SHEEP INVESTIGATIONS.

Rapid progress has been made in the development of the United States Sheep Experiment Station near Dubois, Idaho, where all the bureau's experiments in range sheep husbandry are now conducted. During the year 23 miles of substantial wire fence were built, which brings the total up to more than 30 miles. A single area of about 17,000 acres is thus inclosed and protected from the roaming live stock of the range. A tract of 400 acres near the main headquarters has been divided into five pastures of 80 acres each, which are used for pen-breeding experimental sheep and grazing studies. A monolithic concrete silo, 14 feet in diameter and 50 feet high, a stockade, and a shed for storing grain and sheltering the camp tender's team were erected at the winter headquarters, about 2 miles south of the main headquarters.

The principal lines of investigation conducted at this station are (1) the breeding of a heavy-shearing type of Rambouillet sheep with desirable mutton form, (2) a study of different types of crossbred sheep for the purpose of producing that type best suited to the western ranges, (3) a comparative study of different methods of utilizing range land for sheep grazing and different methods of supplying water on dry ranges, and (4) the production on arid lands of crops that may be utilized for the winter feeding of sheep.

The Rambouillet flock consists of 783 ewes and 17 bucks. The crossbred flock consists of 917 ewes and 18 rams (including Corriedales). Two principal types of crossbreds are being studied, namely, the Corriedale, using as the foundation stock individuals that were imported from New Zealand in 1914, and the Columbia, a type that has been developed at the station from a Lincoln-Rambouillet foundation. The Columbia so far has returned the most wool and mutton, while the Corriedale has produced wool that appear to be somewhat superior in character. The Corriedale has proved its

adaptability to our ranges, but the Columbia has seemed to be more robust and larger. Lambs of the Columbia breed are heavier at weaning time than the Corriedale lambs, so that there appear to be some economic advantages in the Columbia. It appears that there are advantages in both breeds that might possibly be combined by crossing them. This has already been begun by mating Columbia ewes with Corriedale bucks.

Scouring tests were made of the fleeces of 40 sheep (20 Rambouillet and 20 crossbred) to compare shoulder samples with the entire fleeces from which they were taken, with the result that the mean contents of grease, dirt, and clean wool were found to be practically the same in the shoulder samples as in the whole fleeces.

FARM SHEEP DEMONSTRATIONS.

The demonstration and extension work relative to farm sheep was carried on in cooperation with the college extension divisions of 13 States, but the bureau's participation was withdrawn at the close of the fiscal year, as already explained. This work included demonstrations in sheep management, including docking, castration, shearing, culling, and treatment for parasites, as well as the introduction of better breeding stock, the promotion of boys' and girls' clubs, assistance in cooperative wool marketing, instruction in grading wool, and encouraging the larger consumption of lamb in the diet. The specialists took part in 1,264 meetings and demonstrations, with audiences aggregating more than 44,000 persons, aided in forming 28 organizations with 582 members, visited 975 farms, and were instrumental in placing 143 purebred sheep.

MILK-GOAT INVESTIGATIONS.

The improvement of milk goats by the use of purebred sires has been continued at the Beltsville farm. All does on hand are descended from the line of breeding that was begun by the bureau in 1911, when common American does purchased in the South were bred to purebred Toggenburg and Saanen bucks. The two lines of breeding have been kept separate. The herd now consists of 39 goats. Investigations are also conducted in the production and use of goat's milk. Feed and milk records are kept and butterfat tests are made. Milk has been furnished to a hospital for a study of its use for infant feeding.

HORSE AND MULE INVESTIGATIONS.

BREEDING AMERICAN UTILITY HORSES.

In the work for the development of a breed of native utility horses for general farm and ranch work, conducted in cooperation with the State of Wyoming at Buffalo, Wyo., there were in the stud at the close of the fiscal year 13 mature stallions, 24 mature mares, 3 three-year-old mares, 4 two-year-old stallions, 2 two-year-old mares, 8 yearling stallions, 3 yearling fillies, and 6 suckling foals, a total of 63 animals. Three of the mature stallions (Carmon, Albion, and Harvest Aid) are retained at the station for use in the stud and for public service to mares brought to the station, and the remaining 10 have been leased for public service in Colorado, Wyoming, and Nebraska.

There has been a good demand for stallions and many more might have been distributed for public service had they been available. The standard of the stud is steadily improving.

BREEDING MORGAN HORSES.

At the close of the fiscal year there were in the stud at the Morgan Horse Farm, Middlebury, Vt., 3 mature stallions, 21 mature mares, 1 four-year-old mare, 1 three-year-old stallion, 4 three-year-old mares, 1 two-year-old stallion, 3 two-year-old mares, 4 yearling stallions, 8 yearling fillies, and 9 suckling foals, a total of 55 animals. The stallions Linsley, Magistrate, Melvin, Mandarin, and Dewey were transferred to the Remount Division of the War Department for use in its breeding work.

The stallion General Gates (666), the premier stallion of this project since the work was started, died December 13, 1920. The brood mare Ellen died January 23, 1921. Ellen was a wonderful producer in the stud, having produced 15 colts, 14 of which were fillies and 1 a stallion. The mares Calve and Faith have been transferred to Washington for the use of the Secretary of Agriculture, and are considered the most attractive carriage pair in Washington. The famous mares Ruby and Laura Jay were recently purchased from the estate of H. R. C. Watson and placed in the stud. Troubadour of Willowmoor (6459) has proved to be a very satisfactory sire in the stud, having produced colts of uniform type and quality.

Records indicate that there has been a gradual increase in the weight and height of the horses maintained in the stud at Middlebury. The average height of mature stallions was 14.3 hands in 1911, 15 in 1916, and 15.1 $\frac{1}{2}$ in 1921; mature mares, 14.2 $\frac{1}{2}$ in 1911, 14.3 in 1916, and 14.3 $\frac{1}{2}$ in 1921. The average weights were as follows: Stallions, 1,025 pounds in 1911, 1,040 pounds in 1916, and 1,200 pounds in 1921; mares, 1,025 pounds in 1911, 1,049 pounds in 1916, and 1,063 pounds in 1921.

FARM POWER STUDIES.

The bureau cooperated with the Bureau of Farm Management and the Bureau of Public Roads in making an economic study of the cost and utilization of power on farms in the Corn Belt with special reference to the effect of the introduction of the tractor. A study of 286 farms in Ohio, Indiana, and Illinois was made by the questionnaire method. The study will be continued in other areas. Results have been reported through the Farm Power Committee of the department as joint contributions of the three bureaus.

POULTRY INVESTIGATIONS.

POULTRY FEEDING.

The number of pens of fowls in feeding experiments was increased somewhat during the year, making a total of 33 pens containing approximately 1,025 fowls. Six pens of yearling hens were carried over the second year on the same rations. In the remaining pens, all made up of pullets, feeding tests previously conducted were continued and new tests were made in which fish meal, tankage, gluten meal, kafir, and varying percentages of other feeds were tried. Egg production was considerably greater than in recent years, due largely to more favorable weather conditions during the winter.

A new mash tested for the general-purpose breeds, such as the Wyandottes and Plymouth Rocks, has given markedly increased production over the mash previously used for these breeds. This mash is composed of 1 part bran, 1 part middlings, 3 parts corn meal, $1\frac{1}{2}$ parts meat scrap, 2 parts ground oats, 5 per cent linseed meal. Pens carried for their second year on a mash containing only 15 per cent meat scrap are giving very good results. A higher meat-scrap mash apparently does not increase production materially for such breeds during their second year, while the tendency for them to become overfat is much more marked with the higher meat-scrap mash.

Gluten meal used as a vegetable protein, to complete previous tests conducted with vegetable protein, is giving excellent results and so far appears to give a higher egg production than any of the other vegetable proteins tried.

In the repetition of the garbage test the results have been fair, but, as in previous years, the mortality has been excessive.

A pen on mash without meat scrap, in a repetition of a test made several years ago, verified the previous test in that the hens laid but few eggs during the winter weeks.

Mashes containing fish scrap and tankage are both giving very good results, the fish scrap giving higher production than the tankage. Several tests with various kinds of fish meal, including fish scrap of a high oil content, indicated that such feeds were not injurious to poultry. No bad effects on the flavor or taste of either eggs or poultry meat have been observed in any of the fish-scrap experiments.

A test using semisolid buttermilk as a drink for laying hens without green feed has given good production, indicating that the buttermilk may be used to replace green feed to advantage.

Kafir used in the scratch mixture in place of corn (maize) indicates that these two feeds have about the same value for poultry, the egg production having been almost identical.

POULTRY BREEDING.

Approximately 1,400 hens were trap nested, about 1,000 of these being pullets and the rest older hens. The varieties kept in greatest numbers are the Single Comb White Leghorn, Single Comb Rhode Island Red, Barred Plymouth Rock, and Lamona. There are smaller numbers of the Single Comb Buff Leghorn, White Plymouth Rock, White Wyandotte, Dark Cornish, Dark Brahma, Light Brahma, Black Hamburg, Silver-Spangled Hamburg, White Minorca, and Buff Orpington.

The main purpose of the breeding work, which has been in progress for several years, is to improve the egg-producing qualities of the stock while at the same time maintaining and improving the standard excellence or quality. The greatest success in bringing about such a combination is with the White Leghorns. Some progress has been made with the Rhode Island Reds, while notable improvement has been made in the production of the Barred Plymouth Rocks. The general egg production of the present laying year, from November 1, 1920, has been better than in any other year.

Following the custom of several years, specimens of the stock at the Beltsville farm were exhibited at the Madison Square Garden

Poultry Show in New York. The excellence of these birds and their high records of production attracted the attention of visitors and were the subjects of extended editorial comment in the poultry press.

The new breed which has been the object of nine years' work has developed to such a point, and its characteristics have become so well fixed, that it has been given a name—Lamona. This name was chosen, with the approval of the Secretary of Agriculture, in recognition of the efforts of Harry M. Lamon, senior poultryman, in conceiving and developing the new breed. The original intent was to evolve a breed of the general-purpose type which should lay a white egg, none of the previously existing general-purpose breeds possessing this character. Other characteristics of the new breed are white color, good body length and breast development, yellow legs, beak, and skin, four toes, and red ear lobes. At present the breed shows all these characteristics with a high degree of uniformity except the combination of white eggs and red ear lobes, which has not become fully fixed, though numerous hens possessing these features have been produced. The breed may be definitely considered as established, although further time is needed for its perfection in a few details. An account of the development of the Lamona breed was published in the *Journal of Heredity* for January, 1921.

An experiment begun last year and continued this year consists of an effort to improve the egg production of a flock without trap-nesting, depending upon external evidence of good production: especially the time of molt in the fall, as a basis for the selection of the better layers.

SOUTHWESTERN POULTRY INVESTIGATIONS.

Great interest is being manifested by the people of the Salt River Valley, in Arizona, in the poultry work being conducted at the bureau's poultry experiment station near Glendale. On November 20, 1920, a field day was held at the station, with an attendance of more than 200 persons. The station before that was at a somewhat inaccessible spot several miles from Glendale. Last winter the people of the community took subscriptions to purchase a tract for a new location nearer the town. The success of the effort is noteworthy in view of the economic condition of the Valley at the time. Ten acres of good irrigated land at the edge of the town were selected and turned over to the department without cost. The community held quite a celebration of the event. "Chicken Day" was held on May 20, 1921, when formal proffer of the site was made by the acting governor of the State to a representative of the Secretary of Agriculture. Schools and business houses were closed and nearly 5,000 people attended. The dean and director of the Arizona College of Agriculture and Experiment Station was present and pledged his cooperation to the poultry station. The Secretary has accepted the offer of the new site.

The ostrich investigations have been discontinued and the ostriches at the station have been lent to the National Zoological Park, Washington, D. C. The work of this station is to be regional in scope and will be devoted to the broad problems of poultry production in the Southwest. Already data have been obtained which indicate that the general-purpose breeds will thrive in that locality.

EGG-PRESERVING TESTS.

Several tests in the use of water glass and limewater for preserving eggs for home use were repeated and both substances continued to give satisfactory results. Four different grades of commercial water glass in which the specific gravity varied materially were tested. All gave good results, but one with a hydrometer test of 41.8 appeared to be the most satisfactory, although slight variations, either higher or lower, did not make a marked difference in the results. There was no direct ratio between the specific gravity and the market price of these solutions.

Limewater without salt gave slightly better results than when salt was used. Air-slaked lime did not give so satisfactory results as lump lime. Galvanized receptacles were used successfully for limewater tests when the pails were thoroughly coated with melted paraffin previous to use.

Tests in which eggs were wrapped in tinfoil and waxed paper and kept in an open cellar or room were entirely unsatisfactory. The tinfoil reduced evaporation to a negligible quantity, but the eggs became musty within a short time.

POULTRY EXTENSION AND POULTRY CLUBS.

Activities in poultry husbandry extension were confined to poultry clubs. All poultry extension work was discontinued June 30, 1921.

Supervision of boys' and girls' poultry clubs, in cooperation with State agricultural colleges, was continued only in North Carolina, South Carolina, Oklahoma, and Iowa. Good progress was made in each of these States and a marked increase was shown especially in standardbred poultry. More than 20,000 members were enrolled. The bureau's cooperation in the poultry-club work in South Carolina was discontinued December 31, 1920, because of the resignation of the agent, and the work in the other three States was discontinued June 30, 1921, because of lack of funds. The States, however, have taken over the agents and are continuing the work with some modifications.

PIGEON AND SQUAB INVESTIGATIONS.

A new loft has been built for the young Homing pigeons, and the number of these birds has been nearly doubled. A splendid loft of excellent type for flying purposes has been produced. Some of the bureau's birds competed in races in the fall of 1920 and made an excellent showing, winning first, second, and third places in the 200-mile and 300-mile flights. In the races for old birds in the spring of 1921 the bureau's loft won first, second, and third in both the 400 and the 500-mile races and easily made the best average speed of all lofts for the entire season. Thirty-five lofts competed in 1920 and 40 in 1921. In the three years in which the bureau has competed in these Homing pigeon races its birds have won first, second, and third places at every station.

Considerable additional data have been obtained regarding the squab-breeding pigeons, including feed consumption, number of squabs produced, and growth and weight of squabs. A large percentage of the older birds have been culled out and replaced by younger and more productive stock.

ANIMAL GENETICS.

The study of the effects of inbreeding and crossbreeding has continued, with results in full harmony with those previously obtained. A series of papers has been prepared, describing the results through the calendar year 1919.

Experiments on the factors which affect the resistance of guinea pigs to tuberculosis have been continued in cooperation with the Henry Phipps Institute of Philadelphia. The results of the preceding year as regards the marked hereditary differences among different inbred families and the lack of importance of differences in age, weight, and rate of gain have been completely confirmed. The most important new results are in connection with a detailed study of the results of all possible crosses among five inbred families. The crossbreds are in general at least as resistant as the more resistant parental family. In particular crosses they are very much more resistant, each family appearing to supply something lacking in the other. A simple Mendelian hypothesis is suggested by the results and is now being tested.

In continuation of the analysis of systems of mating, methods have been devised of measuring directly the amount of inbreeding and the effects to be expected in any actual pedigree, and also of measuring the degree of resemblance to be expected between any two individuals in such a pedigree.

The study of the genetics of special traits of the guinea pig has been continued. The work in this connection has brought to light certain peculiar interrelations between the production of black and yellow pigments in the fur, which probably apply to all mammals. A number of new color varieties have been produced by combinations of Mendelian factors.

ANIMAL HUSBANDRY EXPERIMENT FARM.

The Animal Husbandry Division farm at Beltsville, Md., has completed its eleventh year. It continues to provide facilities for research work in genetics, sheep and goat husbandry, swine husbandry, and poultry husbandry, and its program of work has been made in accordance with those projects. Each project has an allotment of ground for feed lots and crop use, and the surplus area is used for emergency needs.

CERTIFICATION OF ANIMALS IMPORTED FOR BREEDING PURPOSES.

Under the provisions of paragraph 397 of the tariff act of October 3, 1913, the bureau issued certificates of pure breeding for 136 horses and 307 dogs for importation for breeding purposes.

DAIRY DIVISION.

The work of the Dairy Division was under the direction of B. H. Rawl, chief, up to February 15, 1921, when Mr. Rawl relinquished the duties of that position and was succeeded by Dr. C. W. Larson, who until then had been assistant chief of the division.

The activities have been largely concentrated on certain definite lines of extension and research which offered special opportunities and represented particular needs. The more general extension work,

having served its purpose, was discontinued. Cooperative projects have been discontinued except where certain problems in improving production or manufacture served more or less as demonstrations. The research work has been directed more largely to fundamental problems in breeding, feeding, and manufacturing. Progress has been made in studies of factory and milk-plant efficiency.

DAIRY EXTENSION.

Dairy extension work, carried on in cooperation with State agricultural colleges, has centered largely around bull associations, cow-testing associations, and extension of the cheese and butter industries in the South and West.

SOUTHERN DAIRYING.

The work in the South consists in the extension and upbuilding of the cheesemaking and creamery industries, together with the development and improvement of general dairy farming among the patrons of the new cheese factories and creameries.

The efforts of the creamery specialists have been directed toward improving the quality of milk and cream delivered to creameries, the quality of the butter produced, and the general efficiency of management. Considerable attention has been given also to the production and handling of milk and cream, and assistance has been given in the management of dairy farms and the erection of silos and dairy buildings. Extension agents also assisted in establishing a number of new creameries, furnished plans for buildings, and aided in installing machinery. In a number of the creameries ice cream is being made as a side line, and the extension specialists have rendered valuable service in regard to methods of manufacture and the installation of machinery for this business. In Mississippi and Tennessee the production of butter increased 50 per cent during the year.

In the work for the development of cheese manufacturing in the southern mountain regions the building of new factories was encouraged where conditions were favorable and attention was given to improving the quality of milk delivered to the factories and improving the quality of the cheese made. Improvement has been brought about by personal aid and short courses of instruction for cheesemakers and by visits to dairymen supplying milk to the factories. High prices of materials and equipment which farmers buy, and low prices for their products, have kept down the volume of cheese-factory business and hindered organization of new factories, though some gains have been made. Two new factories were organized in Tennessee and one in Georgia.

In North Carolina a systematic and successful effort was made to improve the quality of the output so as to command better prices. Dairying is becoming an established business in the southern cheese area, and despite the low prices there is better interest than ever before. About 90 silos have been built in this territory.

WESTERN DAIRYING.

Efforts of the extension forces in the western territory have been directed toward improving the dairy cattle by means of cow-testing and bull associations and improving the quality of milk and other dairy products through assistance to milk plants, creameries, and

cheese factories. An active campaign with the cow-testing associations resulted in the elimination of all scrub bulls in 15 of the 51 associations in this territory. An effort is being made in these associations to bring about the general requirement of tuberculosis-free herds headed by purebred bulls. One new bull association was organized and bulls were purchased for it.

The creamery extension agent visited 122 factories in six States. The better care of milk and cream on the part of creamery patrons was advocated, and creameries were urged to grade the cream.

In the work for cheese improvement 160 factories were visited. Their greatest need was found to be the further improvement of the quality of the milk. Accordingly meetings of the milk producers were called, with the cooperation of farm bureaus and factory managers, and illustrated lectures were given, with good results.

Efforts for the improvement of market milk were also continued. "Surprise" milk contests were held, pasteurizing plants were examined, talks on clean milk production were given, aid was given in planning milk plants, a students' contest in judging products was supervised, and help was given on individual problems.

COW-TESTING ASSOCIATIONS.

The promotion and supervision of cow-testing associations, whose object is to increase economically the average milk and butterfat production of dairy cows, has been continued. On July 1, 1921, there were in operation 452 associations, including 11,209 herds and 193,928 cows, as compared with 468 on July 1, 1920. This slight decrease is attributed to the depressed condition of the dairy industry. Four field agents, working in cooperation with State agricultural colleges, have aided in organizing new associations and reorganizing old ones and have given assistance to county agents and herd owners. Much good has been done toward eliminating inferior sires. In Wisconsin, for example, 335 purebred bulls were purchased last year, and practically 90 per cent of the 3,028 cow-testing association members are using purebred bulls. In Minnesota, where there are 23 active associations, all but two are free from grade and scrub sires.

A study of cow-testing records, as a means of determining the best methods of cooperation, organization, and herd management, has brought to light the following facts: Yearly records of 21,234 cows showed an average yearly milk yield of 6,077 pounds; butterfat, 248 pounds; income over cost of feed, \$62.70; returns for each dollar expended in feed, \$2.13. In all cases profits went up rapidly as production increased. This was true regardless of breed, age, weight, date of freshening, or geographical location. Fall-freshening cows generally give more product, both milk and butterfat, and more income, both gross and net; but this rule is not universal. For each breed high butterfat test goes with high butterfat production, but not with high milk production. The higher the average production of fat, the higher the average fat test; but the higher the average production of milk, the lower the average fat test. Large-producing cows of all breeds are the profitable ones; that is, a large yield from one cow is more profitable than the same amount from two or more cows. This is especially true when the product is sold as whole milk.

BULL ASSOCIATIONS.

Bull associations, which have for their object the improvement of dairy cattle through the cooperative ownership and use of good pure-bred sires, are likewise encouraged and supervised. Notwithstanding some curtailment of the extension forces, the number of associations increased from 123 on June 30, 1920, to 158 on June 30, 1921. The number of members increased from 4,153 to 5,064, owning 672 high-class bulls. Publicity in acquainting dairymen with the purpose and benefits of the association has proved an effective aid to the personal work of the extension men. Safe methods of handling bulls were introduced, and a large number of blue-prints of bull pens designed for this purpose were furnished to dairymen.

COMBATING INFECTIOUS DISEASES IN DAIRY HERDS.

Disease control in bull associations and cow-testing associations is fast becoming an important part of the work of such organizations, and the Dairy Division encourages this policy. In some States all herds must be tested and the reactors taken out before the association bulls are used, and this practice is becoming more general. Meetings have been held in various parts of the country to instruct farmers in disease control. Studies in the control of abortion have been taken up at the Dairy Experimental Farm at Beltsville, Md.

UTILIZATION OF DAIRY PRODUCTS.

Campaigns to promote greater consumption of milk and other dairy products in cities, towns, and rural districts have been carried on by the Dairy Division and the States Relations Service of the department in cooperation with State agricultural colleges and local agencies. Such campaigns have been conducted in 9 States, 15 cities, and 4 counties, and in all cases substantial increases in consumption of dairy products have been reported, the increase in milk sales averaging more than 15 per cent. Nutrition clinics were held in most places, and undernourished, underweight children made extra gains in consequence of milk feeding. Through the increased use of milk the health of children has been improved and much undernourishment eliminated. The cooperative campaigns in some States have been followed up and further campaigns have been conducted by the State forces alone, either State-wide or in numerous localities.

DAIRY MANUFACTURING INVESTIGATIONS.

CREAMERY DEVELOPMENT AND IMPROVEMENT.

Special attention has been given to problems of efficient creamery operation. In an effort to devise better and more economical methods of manufacturing dairy products, a special study has been made of the unit cost of producing various products, such as cheese, butter, and condensed milk. Such information is essential to better management and increased efficiency, especially where more than one product is made in the same factory.

THE GROVE CITY CREAMERY.

The products made during the past year at the cooperative creamery at Grove City, Pa., under the supervision of the Dairy Division, have included butter, condensed skim milk (plain and sweetened), and Swiss, Roquefort, Camembert, Cheddar, and cottage cheese. Some experimental Pecorino cheese was made, also some experimental club cheese composed of half Roquefort and half Cheddar. The making of comparatively large quantities of Roquefort, Swiss, and Camembert cheese has afforded an opportunity for study and improvement in manufacturing methods, and has demonstrated that these varieties of cheese, heretofore largely imported, can be made successfully and profitably in this country. Because so much of the milk was used for making cheese, less butter was made than in the preceding year. The butter which is made from pasteurized sweet cream has continued to give great satisfaction. Studies have been made in regard to conditions of milk production in the territory of the creamery, with a view of procuring a supply of raw material of suitable quality for making fancy cheese during the entire year. Improvements have been made in the methods of manufacturing Camembert cheese, enabling the creamery to make 60 dozen a day, which is double the maximum of previous years. Improvement has also been made in the manufacture of Roquefort cheese on a commercial scale.

BUTTER FOR THE NAVY.

Under the supervision of the Dairy Division, 1,218,204 pounds of butter was packed for the Navy in 11 creameries during the season of 1920. Of this, 767,987 pounds was packed in tins, 100,050 pounds in cubes, and the remainder in tubs. Tub samples 10 months after storing were found to be in excellent condition and of very uniform quality.

RENOVATED-BUTTER INSPECTION.

The inspection of renovated-butter factories was conducted at 11 plants, whose output was 6,134,034 pounds, a decrease of 3,507,641 pounds from the preceding fiscal year. In most cases the inspection was made by meat inspectors of the bureau, under the general supervision of the Dairy Division. The packing stock used is carefully inspected.

STUDENTS' JUDGING CONTEST.

The fourth annual students' contest in judging dairy products was held under the supervision of the Dairy Division at the National Dairy Show in Chicago in October, 1920.

DAIRY RESEARCH LABORATORIES.

NUTRITION OF DAIRY COWS.

Studies of the mineral requirements for milk production have been continued and a bulletin (Department Bulletin 945) has been published on the effect of calcium and phosphorus on the milk yield of dairy cows. An attempt has been made to determine under what conditions cows are likely to suffer from lack of calcium and phosphorus. The results are incomplete, but seem to indicate that making up the deficiency with extra supplies of these nutrients has a

beneficial effect on the milk yield, and that both low calcium and low phosphorus produce characteristic changes in the blood of the animals.

Experiments have also been made to show the effect of variations in the ration on amino acids in the blood plasma and on the milk yield.

Reduction of the carbohydrates in the ration, reduction of the protein, and reduction of the whole ration have been found to produce different characteristic results on the yield and composition of milk and on the blood plasma.

BACTERIOLOGY AND CHEMISTRY OF MILK.

In studying the bacteriology and chemistry of milk some distinct contributions have been made to our knowledge of the nutrition of bacteria. Various neutral salts have their characteristic effect on the growth of bacteria, and may be arranged in a scale according to their beneficial or detrimental influence. It has been found that both streptococci and bacteria of the *bulgaricus* type are stimulated by the presence of fats in the medium. It has been found that vitamins are not the sole cause of this stimulation.

Means have been found of differentiating the hemolytic streptococci commonly found in fresh milk from the virulent type of human origin, and a color test has been devised which makes differentiation easy.

The changes in milk which accompany heat coagulation have been studied, and a test has been found for the curdling point.

RESEARCH ON MANUFACTURE OF MILK AND CREAM PRODUCTS.

The cause and methods of control of "sandiness" in ice cream, a problem of importance in commercial ice-cream making, have been determined. Sandiness is due to large crystals of lactose. It can be controlled by methods of making and handling. Incidental to this work a thermocouple has been invented which will indicate the temperature on the inside of the freezer while in operation. Directions for calculating mixes for ice cream were issued.

Investigations on the coagulation of evaporated milk in sterilizing have been continued. Albumen has a stabilizing effect on the casein, and by increasing the albumen content of the milk the sterilizing temperature may be raised materially.

The alcohol test for determining the quality of milk for condenseries has been found useful.

In the investigation of problems in the manufacture of cheese of the Swiss type, the causes of "nissler" or "blowing" cheese and of "glass" or "blind" cheese have been studied and means of control have been partially worked out.

Improvement has been effected in the methods and results of making Roquefort cheese at the Grove City Creamery. The yellow color which is objected to by some consumers has been reduced by using milk from cows on dry feed.

UTILIZATION OF CREAMERY BY-PRODUCTS.

Experiments have shown that considerable quantities of skim milk can be utilized by making it into low-fat cheese of Greek and Italian types. Excellent Pecorino cheese has been made in the laboratory, and this product will be tried on the market.

Progress has been made in studying the obscure problems concerned in the deterioration of milk powder. Moisture content is evidently a factor in the decrease in solubility and increase in "tallowiness." A vacuum drum for drying milk has been installed at Grove City. This will be used to make soluble whey proteins by a process on which a patent has been granted. Concentrated whey has been found valuable for pig feeding.

SILAGE INVESTIGATIONS.

Satisfactory silage has been made from a combination of Sudan grass, soy beans, and cowpeas. The most satisfactory mixture, for both yield and palatability, was Sudan grass and cowpeas. Since the Bureau of Plant Industry is taking up this work on an extensive scale, the work in the Dairy Division will be discontinued.

MARKET MILK INVESTIGATIONS.

DAIRY SANITATION.

In the course of activities in behalf of dairy sanitation 25 cities in 11 States were visited during the year. In five of these cities intensive work for improvement in sanitation was done and in the remainder research work was carried on. Milk contests were held in four cities. An extensive survey of two months' duration was conducted at St. Louis, Mo., on the request of the board of aldermen. A report has been prepared, with recommendations for a new ordinance and its proper enforcement. Other surveys were made at New Haven, Conn., and Norfolk, Va., with satisfactory results.

The monthly circular letters to milk plants and to health officers have been continued and have resulted in improvement in the quality and economy in the handling of milk supplies. The inspection of milk supplies delivered to Government buildings has been continued.

Inspections were made of the Beltsville farm dairy and the Naval Academy dairy. At Beltsville the high scores of the preceding year were maintained, and the Naval Academy dairy has made distinct improvement. At Grove City studies of farm conditions were made to find out what practices were detrimental to the successful manufacture of Swiss cheese, and certain changes were recommended which have brought about improvement.

MILK-PLANT MANAGEMENT.

Data gathered previously in the field have been compiled and published as Department Bulletin 849, "City Milk Plants: Construction and Arrangement," and Department Bulletin 890, "Milk-Plant Equipment." Twenty-nine sets of stock plans of milk plants have been sent out, personal aid has been given in planning special plants, and information has been supplied in regard to equipment, systems of management, and other subjects related to milk-plant operation.

An extensive study of the losses of milk between the farm and the milk plant was undertaken at the request of the mediator of milk prices at Baltimore, as a result of numerous complaints by producers. The work occupied a month or more, and consisted in examining and

following milk shipments from the country platform to the city plant. Shortages in filling the cans were found which amounted to 1.21 per cent of the total. In other words, farmers were shipping cans not quite full, but claiming returns on them as full cans. There was also a shortage of 2.56 per cent between the quantity shipped and the quantity credited to the producers, but most of this difference was accounted for by the difference between can measure and weight. Little milk was found spilled on the railroad trains or platforms. At the milk plants there was a good deal of waste from spilling, but usually ample credit was given the shippers for this. This investigation showed that the losses between farm and city, due to carelessness in handling, spillage, theft, etc., were much less than had been supposed; in fact, that such losses were negligible and were not a valid cause of contention between producers and dealers.

REQUIREMENTS FOR MILK PRODUCTION.

Investigations on the requirements and cost of milk production in Vermont, Louisiana, and Nebraska have been compiled and published (Department Bulletins 923, 955, and 972), and similar observations in Delaware have been completed, concluding the series of studies in seven representative milk-producing regions in the United States. Data on the requirements for raising young stock, obtained through these studies, are being compiled.

OTHER ACTIVITIES.

Studies on whipping cream and on the feathering of cream have been continued, and the material on the former subject has been prepared for publication. The work on flavors and odors in milk has been continued, and indicates that there is little foundation for the common opinion that silage-tainted air, during milking, is the chief source of silage flavors and odors in milk. However, observations made in tightly closed barns show that strong barn flavors and odors are found in milk when no ventilation is provided.

Investigations on cleaning milking machines, carried on cooperatively with five city health departments, indicate that heat sterilization is more effective than the chlorin method. The chlorin method left nearly four and one-half times as many bacteria in the milk as the heat method.

DAIRY CATTLE BREEDING.

Comprehensive dairy cattle-breeding experiments which have for their object a greater knowledge of the fundamental principles underlying dairy-cattle improvement have been continued and expanded. Three proved Jersey sires of unusual merit were purchased early in the fiscal year, thus completing the collection of animals for the project in which close inbreeding will be compared with outcrossing. In another breeding project, begun during the year, eight prominent and distinct Jersey families are to be combined in the third generation, to see whether such crossing will give better results than line breeding or inbreeding within these same families separately. Three females from each of four families were purchased as a beginning for this experiment, with the object of mating them to four proved sires representing four other families. Twelve registered Holstein-Friesian

cows were purchased for a foundation herd for a new station at Woodward, Okla.

Breeding projects are being carried on in cooperation with the following State institutions: Clemson College (South Carolina), University of Idaho, Washington State College, New Jersey Experiment Station, University of West Virginia, University of Maryland, and Michigan Agricultural College.

Forty young bulls have been lent to farmers, institutions, and colleges for the purpose of proving their transmitting ability for milk and butterfat production. A number of young bulls from the department station at Huntley, Mont., have been placed on farms and their offspring studied.

Twenty Holstein cows in the breeding projects completed official tests during the fiscal year, ranging from 415 pounds to 823 pounds of butterfat. The average was 16,549.5 pounds of milk and 565.85 pounds of butterfat. The most notable record was made by Helen Uilkje Calamity at the Huntley station. This cow produced 25,499.4 pounds of milk and 823.11 pounds of butterfat.

DAIRY STATISTICS.

The compilation of statistics on the dairy industry in this and other countries has been continued, and information in regard to production, manufacture, and trade in dairy products has been kept up to date for convenient reference. A handbook of dairy statistics of the United States and foreign countries has been prepared for publication. Charts have also been prepared and kept up to date. Reviews of the butter, cheese, and condensed-milk situation for a series of years were prepared jointly with the Bureau of Markets and published in the Market Reporter. Information has also been gathered on the use of milk in making milk chocolate.

DAIRY ENGINEERING.

The engineering staff of the Dairy Division has prepared plans and specifications for various new buildings and engineering construction and has also made surveys, inspected material, and supervised construction at Beltsville and Grove City. Assistance has been given in the planning and construction of refrigeration and heating systems, electrical equipment, sewage systems, and steam power plants, not only for the Dairy Division but for other bureaus and departments. Some remodeling and repairs have been done on old buildings at Beltsville, and plans have been drawn for enlargement of the stables and for a new boiler house and underground heating lines. About 2,000 feet of sewer pipe has been installed. A milk-drying plant has been partially installed at Washington and contracts have been let for an addition to the building at Grove City to provide for condensed-milk investigations. Much technical information has been given to correspondents on dairy engineering problems, and 659 sets of blueprints have been sent out, of which 482 were barn plans. Two bulletins on the control of temperature in laboratories and the transmission of power in dairy plants have been prepared for publication.

MEAT INSPECTION DIVISION.

The Federal meat inspection, conducted by the Meat Inspection Division, with Dr. R. P. Steddom as chief, shows a slight decline (4.7 per cent) in the total number of animals slaughtered as compared with figures for the preceding year, though there was an increase of 5.6 per cent over the average slaughter of the previous 14 years during which the present meat-inspection law has been in operation.

INSPECTION OF DOMESTIC MEATS.

Inspection was conducted at 892 establishments in 265 cities and towns, as compared with 897 establishments in 262 cities and towns during the fiscal year 1920. Inspection was begun at 62 establishments and withdrawn from 61 during the year, as compared with 65 and 57 respectively, during the fiscal year 1920. Inspection was withdrawn from 47 establishments on account of discontinuance of slaughtering or of interstate business, from 5 by request, from 5 on account of consolidation, and from 4 because of violations of the meat-inspection regulations or because of insanitary conditions.

ANTE-MORTEM AND POST-MORTEM INSPECTIONS.

The ante-mortem and post-mortem inspections are given in the following tables:

Ante-mortem inspection of animals.

Class of animals.	Passed.	Sus-pected. ¹	Con-demned. ²	Total in-spected.
Cattle.....	8,044,364	103,529	27	8,147,920
Calves.....	3,863,813	3,554	17	3,867,384
Sheep.....	12,425,061	2,407	16	12,427,484
Goats.....	19,992	31	.....	20,023
Swine.....	37,520,607	69,129	1,599	37,591,335
Horses.....	1,325	10	4	1,339
Total.....	61,875,162	178,660	1,663	62,055,485

¹ This term is used to designate animals found or suspected of being unfit for food on ante-mortem inspection, most of which are afterwards slaughtered under special supervision, the final disposal being determined on post-mortem inspection.

² For additional condemnations see succeeding tables.

Post-mortem inspection of animals.

Class of animals.	Passed.	Con-demned.	Total in-spected.
Cattle.....	8,132,718	46,854	8,179,572
Calves.....	3,888,504	7,703	3,896,207
Sheep.....	12,439,769	12,666	12,452,435
Goats.....	20,004	23	20,027
Swine.....	37,580,257	122,609	37,702,866
Horses.....	1,316	19	1,335
Total.....	62,062,568	189,874	62,252,442

The next two tables show the diseases and conditions for which condemnations were made.

Diseases and conditions for which condemnations were made on ante-mortem inspection.

Cause of condemnation.	Cattle.	Calves.	Sheep.	Goats.	Swine.	Horses.
Edema.....						1
Emaciation.....	2	16	2		33	1
Enteritis.....					5	1
Glanders.....						1
Hog cholera.....					1,065	
Hyperemia.....					2	
Injuries.....	4		6		5	
Mammitis, acute.....	1					
Moribund.....	1		1			
Parasites.....					1	
Pneumonia.....	6		9		128	
Pregnancy and recent parturition.....					3	
Pyemia.....	1				4	
Septicemia.....	1				4	
Temperature.....	4		1	4		327
Tetanus.....	2					
Tuberculosis.....	5					
Tumors and abscesses.....					22	
Total.....	27	17	16		1,599	4

Diseases and conditions for which condemnations were made on post-mortem inspection.

Cause of condemnation.	Cattle.		Calves.		Sheep.	
	Carcasses.	Parts.	Carcasses.	Parts.	Carcasses.	Parts.
Actinomycosis.....	591	120,005	45	1,555		
Adenitis.....						
Asphyxia.....	2		8			42
Blackleg.....	8		6			
Bone diseases.....	18	9	1	4		16
Caseous lymphadenitis.....					1,089	77
Cellulitis.....						
Congestion.....	4	6	3		6	
Contamination.....	3	1,685		5		3
Cysticercus.....	180	1,117	17	4	114	13
Dropsical diseases.....	8				12	
Emaciation.....	2,313		1,285		3,520	
Fatty degeneration.....					1	
Frozen.....						
Gangrene.....	56		26		6	
Glanders.....						
Hog cholera.....						
Hydronephrosis.....					6	
Icterus.....	97	1	129		1,594	
Immaturity.....	1,576	333	2,825			
Injuries, bruises, etc.....			375	68	628	81
Leukemia.....	291		27		11	
Melanosis.....	29	7	35	4	16	
Moribund.....	6		11		88	
Necrobacillosis.....	2		1	4	20	5
Necrosis.....	2	638	3		5	
Parasitic diseases.....	8	21			9	12
Phlebitis.....			170		1	
Pneumonia, peritonitis, metritis, enteritis, pleurisy, etc.....	5,406		1,234		4,448	
Pregnancy and recent parturition.....	47				57	
Septicemia, pyemia, and uremia.....	2,248		733		827	
Sexual odor.....					1	
Skin diseases.....			1			
Texas fever.....	121		137			
Tuberculosis.....	33,328	51,182	553	438	12	7
Tumors and abscesses.....	510	1,758	78	241	153	56
Total.....	46,854	176,762	7,703	2,323	12,666	270

Diseases and conditions for which condemnations were made on post-mortem inspection—Continued.

Cause of condemnation.	Goats.		Swine.		Horses.	
	Carcasses.	Parts.	Carcasses.	Parts.	Carcasses.	Parts.
Actinomycosis.....			2	131		
Adenitis.....			1	5		
Asphyxia.....			1,051			
Blackleg.....			182	39		
Bone diseases.....						
Caseous lymphadenitis.....	6	8				
Cellulitis.....			19	367		
Congestion.....			39	3		
Contamination.....			162	1,064		
Cysticercus.....			188	16		
Dropsical diseases.....			121			
Emaciation.....	7		745			3
Fatty degeneration.....						
Frozen.....			4			
Gangrene.....			21			1
Glanders.....						1
Hog cholera.....			16,693			
Hydronephrosis.....			8			
Icterus.....			4,002	2		
Immaturity.....						
Injuries, bruises, etc.....	2		1,003	6,628		
Leukemia.....	1		148			
Melanosis.....			68	3		4
Moribund.....			153			
Necrobacillosis.....			8	1		
Necrosis.....	1	1	6	5		
Parasitic diseases.....			78	2		
Phlebitis.....						
Pneumonia peritonitis, metritis, enteritis, pleurisy, etc.....	3		18,822			2
Pregnancy and recent parturition.....	1		167			
Septicemia, pyemia, and uremia.....	1		11,014			6
Sexual odor.....	1		1,200			
Skin diseases.....			81	7		
Texas fever.....						4
Tuberculosis.....			64,830	472,465		
Tumors and abscesses.....		1	1,793	11,394	2	1
Total.....	23	10	122,609	492,132	19	7

The following table shows the total condemnations on ante-mortem and post-mortem inspections combined:

Summary of condemnations.

Class of animals.	Animals or carcasses.	Parts.
Cattle.....	46,881	176,762
Calves.....	7,720	2,323
Sheep.....	12,682	270
Goats.....	23	10
Swine.....	124,208	492,132
Horses.....	19	7
Total.....	191,533	671,504

In addition to the foregoing, the carcasses of 62,836 animals found dead or in a dying condition were tanked, as follows: Cattle, 2,319; calves, 3,412; sheep, 8,921; goats, 30; swine, 48,141; horses, 13.

INSPECTION OF MEAT AND PRODUCTS.

The inspection and supervision of meats and products prepared and processed are shown in the following table, which is a record only of inspection performed and not a statement of the aggregate quantity of products prepared. The same product is sometimes duplicated by being reported in different stages of preparation under more than one heading.

Meat and meat food products prepared and processed under inspection.

Kind of product.	Inspection "pounds."	Kind of product.	Inspection "pounds."
Placed in cure:		Lard oil.....	906,704
Beef.....	125,798,228	Lard stearin.....	638,466
Pork.....	2,501,884,515	Compound and other substitutes for lard.....	339,366,107
All other.....	2,860,691	Oleo stock and edible tallow.....	59,533,605
Sausage, chopped.....	583,776,589	Oleo oil.....	132,475,942
Canned product:		Oleostearin.....	61,387,437
Beef.....	66,569,938	Oleomargarin.....	151,638,073
Pork.....	17,742,728	Miscellaneous.....	1,538,524,862
All other.....	1,927,783	Horse meat:	
Sterilized product:		Cured.....	307,602
Beef.....	3,060,785	Sausage, chopped.....	250
Pork.....	8,515,618	Canned.....	12,987
All other.....	4,270	Miscellaneous.....	2,303
Pork for to be eaten uncooked.....	42,591,582	Total.....	7,127,820,472
Meat extract.....	473,731		
Lard.....	1,487,819,676		

The following quantities of meat and meat food products were condemned on reinspection on account of having become sour, tainted, unclean, rancid, or otherwise unwholesome: Beef, 5,709,184 pounds; pork, 8,120,618 pounds; mutton, 137,538 pounds; veal, 63,284 pounds; goat meat, 539 pounds; horse meat, 48,272 pounds; total, 14,079,435 pounds.

MARKET INSPECTION.

Market inspection, to facilitate interstate deliveries of meats and products, was conducted in 45 cities.

MEAT AND PRODUCTS CERTIFIED FOR EXPORT.

The following products were certified for export: Beef and beef products, 211,974,144 pounds; pork and pork products, 1,422,144,571 pounds; mutton and mutton products, 65,602,452 pounds; total, 1,699,721,167 pounds. In addition, 19 certificates were issued covering the export of 263,287 pounds of horse-meat products, and 1,359 certificates covering the export of 20,465,386 pounds of inedible animal products.

EXEMPTION FROM INSPECTION.

The provisions of the meat-inspection law requiring inspection usually do not apply to animals slaughtered by a farmer on the farm nor to retail butchers and dealers supplying their customers. The retail butchers and dealers, however, in order to ship meat and meat food products in interstate or foreign commerce, are required to obtain certificates of exemption. The number of exemption certificates outstanding at the close of the fiscal year was 2,699, an increase of 77 over the preceding year. During the year 96 certificates were canceled, 85 on account of the dealers' retiring from business or ceasing to make interstate shipments and 11 for violations of the regulations.

During the year 34,969 shipments were made by retail butchers and dealers holding certificates of exemption, as compared with 34,339 shipments during the fiscal year 1920. The shipments of the year consisted of the products shown in the following table:

Shipments by retail butchers and dealers under certificates of exemption from inspection.

Product.	Number.	Pounds.
Beef, carcasses (566 quarters).	141	68,650
Veal, carcasses.	26,935	2,231,534
Sheep, carcasses.	755	39,792
Swine, carcasses.	438	52,853
Beef, fresh.	1,163	368
Veal, fresh.		188,337
Mutton, fresh.		191,161
Pork, fresh.		223,552
Cured meats.		189,964
Lard.		12,258
Sausage.		69,495
Miscellaneous (scrapple, tripe, headcheese, etc.).		27,513
Total.	28,269	4,458,387

During the year 63,939 interstate shipments were made of meat and meat food products from animals slaughtered by farmers on the farm, as compared with 62,983 shipments made during the fiscal year 1920. The following table shows the products composing these shipments:

Shipments of farm-slaughtered products under exemption from inspection.

Product.	Number.	Pounds.
Beef, carcasses (1,467 quarters).	367	138,763
Veal, carcasses.	93,149	7,928,974
Sheep, carcasses.	3,557	145,714
Swine, carcasses.	6,598	742,182
Beef, fresh.		39,568
Veal, fresh.		62,006
Mutton, fresh.		1,521
Pork, fresh.		172,867
Cured meats.		410,911
Lard.		113,331
Sausage.		87,283
Miscellaneous (scrapple, tripe, headcheese, etc.).		19,453
Total.	103,671	9,862,573

INSPECTION OF IMPORTED MEATS.

The following table shows the inspection of imported meats and meat food products for the fiscal year:

Imported meat and meat food products inspected.

Country of origin.	Fresh and refrigerated meats.		Cured and canned meats.	Other products.	Total weight.
	Beef.	Other classes.			
Argentina.	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.
Australia.	2,848,993	12,307,935	1,945,552	780,221	17,882,701
Canada.	52,283	472,843	478,409		1,003,535
New Zealand.	30,817,634	11,723,552	696,831	176,730	43,414,747
Uruguay.	200,657	91,089,268	542,392	2,883,661	94,715,978
Other countries.	856,993	1,195,163	1,842,991	60,617	3,955,754
Total.	320,510	77,000	160,992	511,410	1,069,912
	35,097,070	116,865,751	5,667,167	4,412,639	162,042,627

The following statement shows the condemnations of imported meats and the amounts refused entry on account of lack of foreign certificate or other failure to comply with the regulations:

Imported meat products condemned or refused entry.

Product.	Condemned.	Refused entry.
	Pounds.	Pounds.
Beef.....	240,488	68,004
Veal.....	7,135	550
Mutton.....	168,002	.....
Pork.....	3,364	35,149
Total.....	419,009	103,703

INSPECTIONS FOR OTHER BRANCHES OF THE GOVERNMENT.

By request of other branches of the Government, reinspections of meats and meat food products to determine whether they remained wholesome and conformed to certain specifications were made during the year, as shown in the following table:

Inspections for other branches of the Government.

Branch of Government.	Passed.	Rejected.
	Pounds.	Pounds.
War Department.....	3,377,953	.....
Navy Department.....	74,492,585	1,629,947
Marine Corps.....	3,050,541	65,372
Interior Department (Indian Affairs).....	402,778	11,280
Panama Railroad Co.....	92,002	225
Coast Guard.....	13,980	.....
Shipping Board.....	7,200	8,454
Total.....	81,437,039	1,715,278

LABELING MEAT AND PRODUCTS.

Numerous labels and similar articles were submitted for approval as required by the regulations. A large percentage were disapproved and returned for correction or modification, and 22,790 were approved.

As usual, numerous questions arose concerning the marking of meat and products with special reference to the declaration of the net weight and the designation of such articles. Careful study was necessary in passing upon statements on labels relating to the food value of products in terms of food calories and vitamins. In order to enable the meat-inspection service to pass upon labels containing statements of dietetic experts employed by the meat-packing establishments, questions as to the shortening qualities of various fats were decided through research work conducted by the Office of Home Economics of the States Relations Service.

In view of reports that numerous pork products not previously placed in the category of pork eaten without cooking were in fact consumed in the raw state, extensive investigations were made to determine the proper classification of such products. Pork products known to be customarily consumed without cooking are required to be treated at the time of preparation in a manner which destroys live trichinæ.

MEAT-INSPECTION LABORATORIES.

The laboratory examination of meats and meat food products and of substances used in connection with their preparation at establishments under inspection has been continued in the meat-inspection laboratories maintained in Washington and six other cities. The laboratories also continued to examine meat and products prepared for the Army and the Navy to determine whether they contained any harmful substances and to see that they conformed to the Army and Navy specifications.

The total number of products analyzed during the year was 54,321, of which 53,435 were domestic and 886 imported. Samples of 2,214 domestic and 102 imported products were found not to be in accordance with the regulations. Besides meats and meat food products, the products examined consisted of curing materials, cereals, spices, condiments, coloring matter, denaturing oils, etc. One instance of the intentional use of a prohibited preservative was detected. Of 21,188 waters examined 452 were rejected. All suspicious water supplies are closely followed up.

A study of the effects of fumigation with hydrocyanic acid gas upon meats and substances used in the curing and preparation of meats was carried out in cooperation with the Animal Husbandry Division and the Bureau of Entomology. It was demonstrated that hydrocyanic acid is not absorbed or taken up by meats or other foods and may be safely employed as a means for the destruction of vermin in inspected establishments without the necessity of removing the meat. Orders permitting and governing such fumigation have been formulated and issued.

Samples of lard derived from hogs which were fed on fish meal at the Beltsville farm were examined. This lard was found to be normal in flavor and chemical constants, but contained small amounts of certain highly unsaturated fatty acids which are characteristic of the fat of fish and marine animals and have not heretofore been found to occur in the fat of domestic animals.

As in previous years, all creameries preparing butter used in oleo-margarin have been inspected, and lists have been issued showing those which meet the requirements with regard to pasteurization.

QUARANTINE DIVISION.

Department regulations governing the importation and exportation of live stock, as well as joint regulations of the Treasury Department and the Department of Agriculture for the sanitary handling and control of hides, skins, wool, other animal by-products, hay, straw, etc., offered for entry into the United States, have been administered as heretofore by the Quarantine Division, of which Dr. R. W. Hickman is chief.

INSPECTION AND QUARANTINE OF IMPORTED ANIMALS.

The prevalence of foot-and-mouth disease in various countries of Europe and South America with which the United States has intimate trade relations, the existence of foot-and-mouth disease, rinderpest, surra, and other dangerous animal diseases in Asia and Africa, and the recent appearance of rinderpest in Europe and South America have necessitated care in the matter of live-stock importations. There has been careful adherence to the long-established rule to issue

no permits for the importation of cattle, sheep, goats, or swine from countries in which either rinderpest, foot-and-mouth disease, contagious pleuropneumonia of cattle, or surra exists. The only countries other than those of North America from which cattle or sheep have been permitted importation during the year are New Zealand, Scotland, and the Channel Islands. Because of repeated outbreaks of foot-and-mouth disease in England it was necessary to continue throughout the year the embargo against the importations of cattle, other ruminants, and swine from that country. In view of improved conditions in England, however, the embargo on horses was removed in May, 1921, and these animals were allowed to come forward from both England and Ireland, subject to certain strict precautions. Twenty-two breeding sheep from New Zealand were permitted importation and were shipped directly to San Francisco for quarantine. Fifty-nine purebred goats originating in Switzerland were permitted from Cuba and were imported and quarantined at New York. Livestock importations from Canada and Mexico, consisting chiefly of animals for feeding and slaughter, were considerably less than for several years preceding.

Regulations governing the importation of cattle were amended, effective May 1, so as to provide for the acceptance with dairy and breeding cattle from Canada of a tuberculin-test certificate signed or indorsed by a Canadian Government salaried inspector. A reciprocal change was made in the Canadian regulations applying to cattle of the same class from the United States destined to Canada.

The following tables show the importations of various kinds of live stock through the different ports of entry:

Imported animals inspected and quarantined.

Port of entry.	Cattle.	Sheep.	Swine.	Goats.	Other animals.
New York.....	1,315	4	2	61	479
Baltimore.....	140				11
Boston.....	217	381	12		
San Francisco.....		22			4
New Orleans.....					7
Philadelphia.....					30
Canadian border ports.....	2,026	100	69		125
San Juan, P. R.....					33
Mayaguez, P. R.....					12
Total.....	3,728	507	101	61	701

Imported animals inspected but not quarantined.

Port of entry.	Cattle.	Sheep.	Swine.	Goats.	Horses.	Other animals.
New York.....					247	
Boston.....					63	
New Orleans.....					1	
Portland, Me.....					7	
San Francisco.....		22		2	1	1,518
Key West.....				6	517	
Portland, Oreg.....						11
Miami, Fla.....					38	
Mexican border ports.....	31,196	2,377	154	3,233	5,157	5
Canadian border ports.....	299,981	156,581	1,107	70	7,092	231
San Juan, P. R.....	204		20		50	
Total.....	331,381	158,980	1,281	3,311	13,173	1,765

Inspections were made and the quarantine supervised in the case of 29,057 quail imported from Mexico, under requirements of the Bureau of Biological Survey.

Besides continuing to maintain a veterinary inspector in Great Britain the bureau detailed an additional inspector for service there, to test with tuberculin at the time of purchase any cattle destined to the United States. During the year 1,161 cattle were so tested in Scotland and the Channel Islands, with the following results:

Tuberculin tests of cattle in Scotland and the Channel Islands for importation into the United States.

Breed.	Tested.	Passed.	Rejected.
Aberdeen Angus.....	93	90	3
Ayrshire.....	41	39	2
Guernsey.....	624	621	3
Jersey.....	596	590	6
Shorthorn.....	155	152	3
Highland.....	7	7	0
Total.....	1,516	1,499	17

Five hundred and eighty-three cattle not accompanied by satisfactory tuberculin-test certificates were tested in quarantine after arrival in the United States, and of this number three reacted.

IMPORTATIONS OF ANIMAL BY-PRODUCTS.

The volume of imports of hides, skins, wool, and other animal by-products has not been so great as in certain previous years. However, the percentage of hides and skins accompanied by certificates rendering them eligible for importation without disinfection was greater than during the preceding year, about 77 per cent being so certified, leaving approximately 23 per cent subject to disinfection at tanneries in this country. Tanners receiving uncertified hides and skins for disinfection have shown a disposition to comply with the requirements and to improve sanitary conditions at their tanneries. In the administration of the regulations the bureau has received cordial cooperation from the Customs Division of the Treasury Department, from the Consular Bureau of the Department of State, and from American consuls in foreign countries, who are charged with issuing or approving certificates and reporting on live-stock diseases.

INSPECTION OF ANIMALS FOR EXPORT.

Every effort has been made to make inspections and issue certificates for export live stock as required by the Governments of the various countries to which the animals have been consigned, as well as to administer the regulations of the department governing the inspection, humane handling, and safe transport of export animals. Statistics of the inspection of animals for export are given in the following table:

Inspections of animals for export.

Kind of animals.	To Canada.	To other countries.		Total.
		American animals.	Canadian animals. ¹	
Cattle.....	3,762	30,251	2,067	36,080
Sheep.....	8,355	8,213	.....	16,568
Swine.....	432	517	9	958
Goats.....	54	28	.....	82
Horses.....	2,706	1,051	2	3,759
Mules.....	176	246	.....	422
Total.....	15,485	40,306	2,078	57,869

¹ Animals of Canadian origin exported through United States ports.

Of the cattle inspected for shipment to Canada, 1,687 were dairy cattle and were tested with tuberculin, with 23 reactors, and 2,075 were range cattle and were not tested. For shipment to other countries 878 cattle were tested for tuberculosis. The mallein test was applied to the horses and mules for Canada and to 26 horses for other countries.

In carrying out the regulations governing the overseas transportation of live stock 227 inspections of vessels were made before clearance.

FIELD INSPECTION DIVISION.

The Field Inspection Division, under Dr. A. W. Miller, chief, has continued its activities for the control and eradication of certain diseases of live stock and for the enforcement of certain live-stock quarantine and transportation laws.

ERADICATION OF SCABIES.

In the work of eradicating scabies of sheep in cooperation with State officials, bureau employees made 22,114,154 inspections and supervised 8,273,450 dippings in the field. Live-stock sanitary authorities in several States where this work is not regularly carried on were also assisted in arresting outbreaks of scabies. This disease was found to be quite prevalent in California, Nevada, Wyoming, and Colorado. Considerable progress has been made in Oregon and Idaho, but the situation remains about the same in the other range States. In the sheep-feeding States the conditions have been further improved.

In the cooperative eradication of cattle scabies bureau employees in the field made 2,797,001 inspections and supervised 1,073,696 dippings. Considerable infection was found to exist in a number of the western range States, but the situation on the whole is better than during the preceding year.

Bureau employees, cooperating with State live-stock sanitary authorities and the Office of Indian Affairs in the suppression of an outbreak of mange in horses on the Omaha and Winnebago Indian Reservations and adjacent territory in northeastern Nebraska, inspected 1,462 animals and supervised 1,773 dippings.

ERADICATION OF DOURINE.

The campaign against dourine of horses was conducted vigorously and systematically by the bureau in cooperation with State live-stock sanitary authorities and the Office of Indian Affairs, and good progress was made. No new cases were found in North Dakota, Wyoming, or South Dakota. A small number of diseased animals were discovered in Montana and some further work remains to be done in that State and also in New Mexico. In Arizona, where more than 80 per cent of the affected animals were found, satisfactory progress was made.

The practice of paying one-half the appraised value of affected horses destroyed when they are owned by citizens, such share not to exceed \$100 in any case, was continued. The number of animals tested and the results of the tests are shown in the report of the Pathological Division.

LIVE-STOCK SANITARY WORK IN INTERSTATE COMMERCE.

In the supervision of interstate transportation of live stock to prevent the spread of animal diseases, bureau employees at public stockyards inspected 18,625,203 cattle, 22,658,919 sheep, and 37,763,447 swine. Of these animals 30,293 cattle and 1,825,729 sheep were dipped under bureau supervision to comply with regulations of the department or of the States of destination and 386,130 swine were inoculated against hog cholera and disinfected for shipment to country points for feeding and breeding purposes.

On request of transportation companies and shippers or to comply with laws of States to which shipments were destined, bureau veterinarians inspected 10,672 horses and mules, of which 5,308 were tested with mallein, 1 showing reaction.

Bureau employees supervised the cleaning and disinfection of 39,202 cars in compliance with department regulations or on request of Canadian Government officials, State officials, or transportation companies. Of these cars 15,499 had been used in the transportation of animals affected with communicable diseases.

To guard against the recurrence of foot-and-mouth disease, all ruminants and swine received at public stockyards were given careful inspection by experienced veterinary inspectors specially assigned to that work, as has been the practice for a number of years. No case of this disease was discovered.

ENFORCEMENT OF TRANSPORTATION AND QUARANTINE LAWS.

The bureau has continued to report to the Solicitor of the department, for presentation to the Attorney General for prosecution, cases of apparent violations of live-stock transportation and quarantine laws. Many of these cases have required special investigation on the part of employees, such as interviewing witnesses and examining railroad and other records. The work of collecting evidence and preparing and submitting reports is to a very large extent accomplished by bureau employees at stockyard centers in connection with their other duties, but four employees being regularly assigned to this work.

The enforcement of the so-called 28-hour law has resulted in better facilities being provided for the feeding, watering, and handling of live stock in transit.

TICK ERADICATION DIVISION.

Further progress was made in the work conducted by the Tick Eradication Division, under Dr. R. A. Ramsay, chief, for the suppression of Texas or tick fever of cattle and the eradication of the ticks which transmit this disease.

TICK ERADICATION.

As a result of the work done in cooperation with the authorities of various Southern States for the extermination of the ticks, areas aggregating 32,171 square miles were released from quarantine during the fiscal year. This action makes available 42 additional counties and 13 parts of counties into which better-bred cattle from tick-free territory may be taken without danger of loss from tick fever. A consequent increase in meat and dairy products and in the value of hides may be expected. The following table shows, by States, the territory released:

Areas released from quarantine as a result of eradicating cattle ticks, fiscal year 1921.

State.	Square miles.
Alabama.....	4,049
Georgia.....	7,016
Louisiana.....	647
North Carolina.....	223
Oklahoma.....	4,397
Texas.....	15,839
Total.....	32,171

The continued presence and spread of ticks in certain areas that had previously been released made it necessary to re-quarantine some counties and parts of counties in order to protect tick-free areas in adjacent counties and States from reinfection. This condition arose from the failure of local officials, because of lack of funds, to maintain quarantine over the few remaining tick-infested herds and to complete the eradication of ticks in the released area. In nearly every case, however, the re-quarantine has had the desired effect, and ways and means have been found by local officers and cattle owners to finish the work. It is believed that as a result of this activity many of these re-quarantined areas will be again released from quarantine during the coming year in a condition that will in all likelihood insure their remaining free.

The total area released from quarantine since the beginning of systematic tick eradication in 1906, and remaining free at the close of the fiscal year, amounts to 503,816 square miles, or 70 per cent of the originally infected area.

During the year 34,935,635 inspections or dippings were made of cattle for the eradication of ticks, as compared with 44,813,070 in the preceding year. There were in operation 26,966 cattle-dipping vats where cattle were dipped under Federal or State inspection to rid them of ticks. As an indication that the dipping of cattle is not attended by any great loss or danger it may be stated that the fatalities from dipping were only 16 per million cattle dipped and handled, besides which only 7 per million were injured.

In the territory already released from quarantine there remain here and there a few infested premises or centers of tick infestation which must be held under control until the last tick can be put out of existence. This condition, taken in conjunction with the effort to eradicate ticks from additional areas still under Federal quarantine, means that Federal and State funds have to be spread very thinly over a very large territory. It is therefore difficult to concentrate efforts in certain areas to such a degree as was done a few years ago. The cost of tick eradication is much greater than it was, and less can be accomplished with the same appropriation. County appropriations will have to be greatly increased if satisfactory results are to be obtained.

SHIPMENTS FROM QUARANTINED AREAS.

The number of cattle of the quarantined area shipped under bureau supervision to market centers for immediate slaughter was 617,721, which is a considerable decrease from the preceding year. Many cattle owners in tick-eradication localities have shown a disposition to ship for slaughter as many unprofitable cattle as possible in preference to dipping them. This was done with a view to procuring, after ticks are eradicated, better-bred animals likely to be more profitable for breeding purposes. "Dipped ticky cattle" to the number of 1,789 were shipped to points where inspection is provided and dipping facilities maintained, for further treatment for movement as non-infectious. At public stockyards 51,022 cattle were dipped and certified for movement as noninfected, for which 1,031 certificates were issued. At points other than public stockyards 28,382 cattle were inspected or dipped and certified for interstate movement as non-infected, as provided for in the regulations. To cover the shipments of these cattle 448 certificates were issued.

DIVISION OF HOG-CHOLERA CONTROL.

Activities in combating hog cholera were continued through the Division of Hog-Cholera Control, under Dr. U. G. Houck, chief, in cooperation with State authorities in 31 States.

A reduction in the funds available for field work from \$446,865 in 1920 to \$192,200 in 1921 necessitated the curtailment of the work and a reduction of the force from 140 veterinarians to 54. Bureau representatives gave less attention to the educational features of the project than during previous years, but the State agricultural colleges continued educational work as usual and the county agents and veterinary practitioners rendered valuable assistance to bureau field men. The bureau's efforts were directed especially to preventing the spread of infection from primary outbreaks with the view of saving as many hogs as possible. The mortality from hog cholera in 1921 was 39.3 per thousand, which is a slight decrease from the preceding year.

In the course of this work, 1,202 meetings were held, with an attendance of 50,928 persons, and 3,420 demonstrations in the use of the serum treatment were given, in which 67,295 hogs were treated. Investigations were made on 29,433 farms, 3,888 autopsies were held, 2,268 farms were quarantined, 656 infected premises were cleaned and disinfected, 96,115 farmers and other persons were interviewed, 432 persons were trained in the application of the serum treatment,

and 46,099 hogs were treated under the supervision of bureau veterinarians.

It is evident from the increasing number of calls for advice that swine growers are becoming more interested than ever before in matters relating to breeding, feeding, and farm sanitation. Gradually they are coming to realize that the use of serum and virus is not all that is necessary to immunize and grow swine successfully. The success attained in immunizing young pigs is very encouraging, but many veterinarians are of the opinion that as a safeguard those kept for breeding purposes should be retreated later. The intraperitoneal injection of the serum seems to be the favorite operation for young pigs. The injection of the serum into the ham is discouraged by the bureau.

State laws regulating the distribution and use of hog-cholera virus were strengthened in some States, but there are yet many factors contributing to keep the losses from hog cholera higher than they should be, considering the available facilities to prevent losses. Among the causes which contribute to the continued high losses may be mentioned carelessness in the purchase of new stock, moving diseased swine from infected farms, free range, failure to report outbreaks promptly, delay in having infected and exposed herds immunized, failure to obtain all the facts necessary to make a correct differential diagnosis, and to realize that hog cholera is yet the predominating swine disease, haste and carelessness in administering serum and virus, the use of impotent virus, underdosing, improper care of the animals after treatment, especially improper feeding, and failure to carry out effectual quarantine and disinfection measures.

Under present conditions the complete eradication of hog cholera can not be expected, and until there is a more active display of public sentiment in favor of eradication we must continue to direct our efforts to further reducing the losses through the control of outbreaks of the disease.

TUBERCULOSIS ERADICATION DIVISION.

The work for the control and eradication of tuberculosis of live stock, conducted by the Tuberculosis Eradication Division under the direction of Dr. J. A. Kiernan, chief, in cooperation with State officials and live-stock owners, has continued to show a large increase. Operations were extended during the year to Colorado and Arizona, making a total of 47 States and the Territory of Hawaii which are actively participating in the campaign. For carrying on the field work the bureau has offices in 41 cities in as many States. An average of 194 veterinary inspectors were detailed to these offices during the year, and they were supplemented by an average of 148 veterinarians employed by the States and by about 25 veterinarians employed by counties and farm bureaus. The activities were carried on, as before, under four main projects: (1) Eradication of tuberculosis from pure-bred herds of cattle under the "accredited-herd" plan; (2) eradication of tuberculosis from circumscribed areas; (3) eradication of tuberculosis from swine; (4) testing cattle for interstate movement.

ACCREDITED TUBERCULOSIS-FREE HERDS.

In the eradication of tuberculosis from herds of purebred cattle and the maintenance of a list of such herds officially accredited as being free from tuberculosis, the tuberculin test was applied to 1,366,358 cattle included in 86,687 herds, of which 53,768 head, or 3.94 per cent, reacted and were removed from the herds. The number of cattle tested is nearly double the number for the preceding year. At the close of the fiscal year there were on the waiting list for future testing 14,440 herds containing approximately 216,000 cattle. There have been established as fully accredited 8,201 herds containing 193,620 cattle, while 49,814 additional herds containing 643,233 cattle have passed one test as a preliminary to being accredited, as shown more fully in the accompanying table. The numbers of accredited herds and cattle made increases of 4,831 and 110,634, respectively, during the year.

Herds of purebred cattle accredited as free from tuberculosis and herds that have passed one test up to June 30, 1921.

State.	Accredited.		Passed one test.	
	Herds.	Cattle.	Herds.	Cattle.
Alabama.....	50	2,637	371	10,231
Arkansas.....	22	585	39	822
Connecticut.....	39	939	102	2,467
Delaware.....	37	997	636	4,224
District of Columbia.....	194	815	141	345
Florida.....	59	2,089	1,868	14,986
Georgia.....	9	536	1,182	12,651
Idaho.....	51	1,702	2,455	15,989
Illinois.....	225	5,904	518	9,755
Indiana.....	346	8,544	3,965	34,053
Iowa.....	204	5,527	1,237	25,112
Kansas.....	200	6,167	259	7,788
Kentucky.....	109	1,979	1,243	18,798
Louisiana.....	34	1,247	215	5,317
Maine.....	458	5,155	1,795	17,345
Maryland.....	220	4,405	813	6,857
Massachusetts.....	37	1,100	39	1,517
Michigan.....	198	4,505	2,372	28,821
Minnesota.....	1,002	24,627	1,704	29,515
Mississippi.....	93	1,942	355	9,630
Missouri.....	250	7,133	1,772	24,915
Montana.....	97	5,210	3,111	61,390
Nevada.....	4	278	946	5,229
Nebraska.....	89	2,560	608	7,300
New Hampshire.....	23	750	92	1,239
New Jersey.....	48	1,524	58	1,210
New York.....	114	3,536	1,899	27,129
North Carolina.....	246	4,845	1,182	8,053
North Dakota.....	238	6,241	2,209	39,444
Ohio.....	439	8,357	1,031	13,942
Oklahoma.....	33	1,203	445	6,522
Oregon.....	85	2,228	3,929	44,807
Pennsylvania.....	541	9,204	803	11,317
Rhode Island.....	7	178	8	169
South Carolina.....	60	2,117	389	5,266
South Dakota.....	46	1,117	346	7,175
Tennessee.....	167	5,719	357	7,354
Texas.....	12	444	135	9,290
Utah.....	42	1,687	2,880	17,678
Vermont.....	589	10,552	1,616	24,909
Virginia.....	546	13,323	819	8,544
Washington.....	45	1,417	1,528	8,790
West Virginia.....	96	2,088	617	7,976
Wisconsin.....	787	20,507	1,305	30,892
Wyoming.....			470	6,470
Total.....	8,201	193,620	49,814	643,233

In furtherance of the plan previously adopted for supplementing the work of the official veterinarians by utilizing the services of practicing veterinarians in testing and supervising accredited herds, examinations to determine the fitness of practitioners to engage in this work were held in 31 States and resulted in the establishment of a list of 3,160 accredited veterinarians. The assistance of these practitioners makes it possible to enlarge and expedite the work of establishing and maintaining accredited herds.

ERADICATION OF TUBERCULOSIS FROM AREAS.

The ultimate complete eradication of animal tuberculosis is believed to depend on eradication first in circumscribed areas. Efforts to promote intensive local work in localities where sentiment and other conditions are favorable have therefore been continued. The usual plan is to take a county as a unit of operation and to test systematically all cattle in the county and dispose of the reactors. Several forms of cooperation between the bureau and local authorities have been established in many counties. As a rule the bureau recommends the employment of official county veterinarians to direct and carry on this work.

At the close of the fiscal year 10 counties had completed one or more official tests of all cattle within their borders (3 each in Oregon and Wisconsin, 2 in Mississippi, and 1 each in Washington and West Virginia), campaigns were under way in 49 other counties (in Iowa, Kentucky, Maryland, Michigan, Montana, New York, North Carolina, Oregon, South Dakota, Tennessee, Utah, Washington, Wisconsin, and Wyoming), and in 25 additional counties plans were being made to begin the work soon.

TESTING IN THE DISTRICT OF COLUMBIA.

In recent years the District of Columbia has been kept practically free from bovine tuberculosis as a result of eradication work carried on in cooperation with the District health department continuously since 1909. Tests were made during the last fiscal year on 340 herds containing 1,373 cattle, and 5 reactors, or 0.37 per cent, were detected and removed. The reacting animals were found in herds to which cattle were constantly being added. In addition 182 lots of cattle containing 334 head were tested for entry into the District of Columbia and 13 reactors were removed.

STATISTICS OF SLAUGHTER AND INDEMNITY.

Statistics of the slaughter of reacting cattle, the indemnity allowed, salvage realized, etc., are shown in the following table:

Cattle slaughtered, appraised value, indemnity allowed, and salvage realized in work of tuberculosis eradication.

State.	Number of cattle.	Average appraisal per head.	State indemnity.	Federal indemnity.	Average State indemnity per head.	Average Federal indemnity per head.	Average salvage per head.
Connecticut.....	557	\$80.76	\$20,687.92	\$10,651.14	\$37.14	\$19.13	\$25.59
Delaware.....	1,116	137.49	60,876.11	28,397.30	54.55	25.45	24.95
District of Columbia.....	7	101.43	.....	163.90	.....	23.41	29.17
Hawaii.....	1	.....	163.28	25.00	.....	.....	.....
Idaho.....	477	195.82	14,122.77	14,122.77	29.61	29.61	29.71
Illinois.....	1,480	202.22	52,105.72	51,066.66	35.21	34.52	32.92
Indiana.....	789	259.95	47,926.75	33,177.12	60.74	42.04	34.13
Iowa.....	2,355	234.53	103,751.24	72,640.16	44.05	30.84	35.06
Kansas ¹	380	190.12	27,249.13	12,923.04	71.71	34.01	31.49
Kentucky.....	392	134.83	30,323.26	10,519.83	77.36	26.84	17.66
Maine ¹	540	120.33	35,848.47	13,555.15	66.39	25.10	15.15
Maryland.....	1,385	82.19	28,881.76	28,835.20	20.85	20.82	20.02
Massachusetts.....	11	248.20	600.00	390.77	54.60	35.50	3.79
Michigan.....	789	170.19	56,600.31	29,382.25	71.74	37.23	28.64
Minnesota.....	2,031	65.15	60,659.17	23,633.91	29.86	11.64	22.24
Mississippi.....	57	84.92	2,960.75	1,433.73	51.94	25.24	9.19
Missouri.....	535	205.10	16,283.24	16,089.90	30.44	30.07	28.31
Montana ¹	510	100.33	37,971.80	13,735.71	74.45	26.93	13.69
Nebraska.....	889	264.90	30,866.77	30,655.28	34.75	34.48	32.54
Nevada.....	223	132.99	9,430.35	5,585.85	42.29	25.05	18.75
New Hampshire.....	681	112.08	28,335.69	15,953.46	41.61	23.43	21.59
New Jersey.....	558	281.61	37,117.17	19,175.35	66.52	34.36	33.38
New Mexico.....	1	.....	33.33	33.33	.....	.....	.....
New York.....	8,329	162.61	782,487.25	232,448.92	93.95	27.91	21.69
North Carolina.....	180	205.74	5,096.12	5,096.12	28.31	28.31	30.87
North Dakota.....	1,483	46.35	24,325.78	17,241.33	16.40	11.63	15.32
Ohio.....	896	132.35	65,749.24	27,492.74	73.38	30.68	32.14
Oklahoma.....	674	179.68	51,984.20	24,288.14	76.99	36.04	26.86
Oregon.....	602	168.37	23,599.75	18,305.78	39.20	30.41	23.08
Pennsylvania.....	1,387	205.70	80,072.52	47,139.50	57.73	33.99	26.28
Rhode Island.....	98	318.16	5,155.00	1,976.00	52.60	20.16	32.39
South Carolina.....	142	78.17	2,948.09	2,942.59	20.73	20.72	16.00
South Dakota.....	845	158.47	39,741.26	22,706.13	47.03	26.87	26.92
Tennessee.....	12	250.00	1,200.00	533.20	100.00	44.43	46.50
Texas.....	401	227.48	15,326.04	13,008.32	38.22	32.44	26.72
Utah.....	59	96.18	1,479.20	1,469.10	25.07	24.90	15.79
Virginia.....	637	129.52	21,551.32	16,596.52	33.83	26.05	17.31
Vermont ¹	2,109	66.13	85,932.38	53,573.00	40.75	25.40	8.92
Washington.....	925	174.75	25,759.68	24,990.64	27.85	27.02	30.43
West Virginia.....	264	99.58	14,041.97	6,816.81	53.19	25.82	17.45
Wisconsin.....	2,019	196.26	59,218.25	57,191.15	29.33	28.33	27.31
Wyoming.....	171	112.27	6,792.51	4,202.19	39.72	24.57	15.23
Total.....	37,265	154.79	1,962,838.17	1,012,868.30	52.67	27.18	23.92

¹ Salvage paid to State.

ERADICATION OF TUBERCULOSIS FROM SWINE.

Investigations regarding the extent and source of tuberculosis in swine were continued. The records of the Meat Inspection Division for the nine months ended March 31, 1921, showed that 11.83 per cent of the hogs slaughtered under Federal inspection were infected with tuberculosis. The plan of tattooing hogs shipped to inspected slaughtering establishments in order that tuberculous animals may be traced back to their former owners has been tried with further successful results. In every instance where tuberculosis was traced to a farm through infection in hogs, and the cattle on the farm were tested with tuberculin, reactors were found among the cattle. In the investigations in the hog-raising sections of the Middle West 96

per cent of the tuberculosis in swine was found to be traceable to feeding the hogs on unsterilized skimmed milk or dairy by-products or allowing them to follow dairy or feeder cattle.

INSPECTION AND TESTING FOR INTERSTATE MOVEMENT.

Under the plan of allowing approved practicing veterinarians to make tuberculin tests of cattle for interstate movement, as outlined in last year's report, 7,370 practitioners had been approved and listed for this work up to the close of the fiscal year. Under their supervision 242,708 cattle were tested during the year, and 3,999 reactors, or 1.64 per cent, were removed. On the whole the approved veterinarians have done excellent work.

During the year 36,208 cattle were tested at public stockyards or at other official stations by regularly employed bureau inspectors, and 675 reactors, or 1.86 per cent, were removed.

In accordance with the regulation requiring that a permit be issued for the interstate movement of known tuberculous cattle for immediate slaughter or for return to the original owner for breeding purposes, permits were issued covering 10,815 reactors for immediate slaughter and 47 for return to owners.

METHODS OF TESTING.

In addition to the subcutaneous tuberculin test, which has been in use for many years, the more recent intradermic and ophthalmic methods of applying the tuberculin test have been used to an increasing extent during the year. The official and other veterinarians have made good progress in familiarizing themselves with the technic of the newer tests and with the use of different tests in combination so as to increase the accuracy of results. The combinations principally used have been the ophthalmic and the intradermic, and the subcutaneous and the ophthalmic. A combination of all three tests was sometimes used in herds known to be badly infected. From October 1, 1920, to June 30, 1921, there were tested by the subcutaneous method alone 251,626 cattle, of which 10,189, or 4.05 per cent, reacted; by the intradermic method alone 648,697 cattle, with 24,454 reactors, or 3.77 per cent; by the ophthalmic method alone 3,143 cattle, with 71 reactors, or 2.26 per cent; and by the combination method 162,351 cattle, with 8,270 reactors, or 5.09 per cent.

CONFERENCES, SHORT COURSES, AND PUBLICITY.

The conference on tuberculosis eradication held during the preceding fiscal year having been so successful, arrangements were made for a number of sectional conferences to bring together State livestock sanitary officials, bureau supervisory officers, Federal and State veterinary inspectors, veterinary practitioners, and interested livestock owners, for a discussion of problems in which all were mutually interested. Meetings were accordingly held at Portland, Me., in July, 1920, at Philadelphia in October, at Chicago in December, at Atlanta in May, and at Boston in June. These conferences were of material assistance in advancing the progress of tuberculosis eradication in the sections represented. Short courses of instruction in the eradication of tuberculosis were held by State veterinary associations, with the cooperation of the bureau, at Auburn, Ala., Danville,

Ky., Lansing, Mich., Fargo, N. Dak., and Lincoln, Nebr. These courses served to prepare veterinarians for the examinations for the bureau's list of accredited veterinarians. Numerous conferences were also held in connection with meetings of State veterinary associations. Tuberculosis eradication was given much attention on the programs of these gatherings.

The motion picture, "Out of the Shadows," which was produced during the year, and which presents both the economic and the human-health phases of the bovine-tuberculosis problem, has been widely shown and has had a very favorable reception. The 12 copies owned by the department are in constant demand and about 25 others have been sold to State authorities, organizations, or individuals.

Several articles on tuberculosis eradication were prepared in the division and published in live-stock and veterinary periodicals.

PATHOLOGICAL DIVISION.

The scientific investigation of animal diseases, the testing of veterinary biological products manufactured and marketed under Federal control, and the study of plants poisonous to live stock have comprised the main activities of the Pathological Division, under the direction of Dr. John S. Buckley, chief.

RESEARCH WORK ON DISEASE PROBLEMS.

INFECTIOUS ABORTION OF CATTLE.

The expense of experimental animals necessitated the abandonment of much of the contemplated experimental work pertaining to abortion disease of cattle, and the investigations have been largely confined to acquiring further data relative to the vaccination of animals with a vaccine containing living abortion organisms. Additional evidence that such vaccine can be advantageously employed for the prevention of losses when used in conjunction with sanitary measures has been obtained. The immunity imparted appears to be relative and not absolute, however, not being capable of protecting subjects against excessive exposure to infection. Unbred heifers are seldom if ever permanently infected by the subcutaneous administration of the vaccine. Under experimental conditions in rare instances the udders of milking cows have seemingly been made centers of infection by the treatment, a feature which has caused some doubt as to the advisability of treating subjects other than unbred heifers. Living abortion organism vaccine apparently possesses the advantage of requiring but a single application to render heifers more or less permanently resistant to the disease, a feature which is highly desirable, especially in beef herds, where the cattle are usually handled with difficulty.

A considerable amount of routine work has also been done, as in previous years, consisting in the application of laboratory tests to several hundred samples of blood serum from suspected cases. Correspondence has furnished a means of disseminating information regarding control measures to herd owners.

ERYSIPelas OF SWINE.

Further studies were made of the organism found in cases of urticaria or "diamond skin disease" of swine, which organism showed characteristics identical with those of the organism causing erysipelas of swine in Europe. The results of comparisons by means of the complement-fixation test seem to establish definitely the close relationship between the organism in question and that of swine erysipelas. The evidence obtained relative to the organism isolated from the skin lesions, particularly in regard to their characteristics culturally and serologically, and also in their pathogenicity for the small experimental animals, seems sufficient to warrant the conclusion that these organisms are a type of *Bacillus erysipelatis suis*, the causative agent of swine erysipelas, and that the disease of urticaria or "diamond skin disease" now existing in the United States should be classed as a chronic form of swine erysipelas, just as it has been considered heretofore in European countries.

AVIAN TUBERCULOSIS IN SWINE.

A continuation of the studies of a local glandular tuberculosis of hogs has resulted in definitely determining the cause of the disease to be a true avian type of the tubercle bacillus. As a result of these findings and numerous field observations it appears quite likely that in certain localities in this country the swine are infected with avian tuberculosis, while the cattle on the same farms may be free from the disease. Some experimental work with the avian tubercle bacillus isolated from the hog showed the organism to agree in all morphological and cultural characteristics with the true bird type, but to possess a much lower degree of virulence than a culture freshly isolated from a bird. The results of tests performed with avian and mammalian tuberculin correspond for the most part with those obtained by Bang in Denmark and Himmelberger in this country. These tests showed that animals infected with bird bacilli reacted more strongly to the avian tuberculin than to the mammalian type. In most instances the latter tuberculin failed to elicit any reaction. A paper reporting this work was prepared for the Journal of Agricultural Research.

BOTULISM.

In cooperation with the Bureau of Chemistry a number of samples of spoiled canned spinach taken from suspected lots was examined and six cans were found to be infected with *Bacillus botulinus*, Type A. Fatal human botulism cases had occurred following the consumption of canned spinach from the same pack. In every instance the infected spinach was extremely toxic, possessed a decidedly disagreeable odor, and the containers were all "hard swells." Some experimental work showed that *B. botulinus*, Type A, is capable of multiplying and producing its specific toxin in canned spinach, although such developments proceed somewhat irregularly. The growth of the organism in canned spinach is accompanied by the production of gas as well as the formation of the toxin.

OTHER INVESTIGATIONS.

In the manufacture of tetanus and diphtheria antitoxin and hog-cholera serum it is customary to remove bacteria by filtration through diatomaceous earth filters. It was desired to ascertain the effect, if any, of such filtration on the potency of the product. Tetanus and diphtheria antitoxin products were filtered through diatomaceous earth and their potencies determined, before and after filtration, by the official method involving guinea-pig inoculation. Filtration did not appreciably diminish potency, though small quantities of protein were absorbed. The effect of filtration on the potency of hog-cholera serum must be inferred, since slight losses in potency can not be detected. Loss of potency may be expected when filtration removes protein from the serum. A method was devised for the more exact determination of coagulable protein in serum, a test that is useful in immunological studies.

DIAGNOSIS OF DISEASES.

TUBERCULOSIS.

The expansion of the work of testing cattle with tuberculin has resulted in a large increase in the number of samples of tissues from reacting cattle in which no visible lesions of tuberculosis were found at time of autopsy that have been forwarded to the laboratory. During the year 1,296 such specimens were received by the Pathological Division for microscopic examination, and tubercle bacilli were found in the specimens from 258 animals.

RABIES.

Specimens from 67 suspected cases were received and submitted to laboratory examination. Twenty-nine proved to be positive, while in 3 cases decomposition prevented a diagnosis. The positive cases were 22 dogs, 1 cat, 1 horse, 1 hog, and 4 cattle. A considerable number of persons, as well as dogs, had been bitten by the affected animals. In every instance in which a person had been bitten, animal inoculation tests were made when the microscopic findings were negative. The specimens were mostly from cases occurring in the District of Columbia, Maryland, and Virginia, with isolated cases from West Virginia, North Carolina, Kentucky, Tennessee, and Colorado. The diminution in the number of cases in the District of Columbia is undoubtedly due to the enforcement of the muzzling order.

GLANDERS.

Cooperative work for the control and eradication of glanders in various States was continued. The complement-fixation test was applied to 483 samples of blood serum from suspected cases of glanders forwarded by bureau inspectors, State officials, and practicing veterinarians, and 43 gave positive reactions.

DOURINE.

The complement-fixation test has continued to be extensively employed for the diagnosis of dourine of horses, 22,855 samples of blood serum having been tested, of which 515, or 2.2 per cent, gave positive reactions.

SARCOSPORIDIA IN HAM.

A number of specimens of muscles of swine, more particularly of cooked hams, showing a peculiar, softened condition, were received for examination. Stained sections made from the small portions of the muscle remaining intact showed a very heavy infection with the small parasite known as sarcosporidia. When the parasites are few in number they apparently cause little or no disturbance in the invaded muscle tissues, but when present in excessive numbers, as in these particular cases, considerable damage to the musculature results.

TESTING BIOLOGICAL PRODUCTS.

The testing of commercial veterinary biological products prepared under Government licenses, as well as the cultures from which these products are made, has been continued and the volume of this work has shown a considerable increase. Three hundred and twelve samples, representing 60 different kinds of products, were examined, and 60 were found to be unsatisfactory by reason of contamination or lack of potency. There were also examined 1,917 cultures, of which 345 were found to be unsatisfactory.

DISTRIBUTION OF BLACKLEG VACCINE.

The manufacture of vaccine for immunizing cattle against blackleg has been continued. As in previous years, the powdered form of vaccine has been made, and this product has been distributed free of cost to stock owners. During the year 1,384,100 doses were distributed.

DISEASES OF SHEEP.

The demand from sheep owners for information concerning diseases of sheep prompted the Pathological Division to prepare Farmers' Bulletin 1155, which was issued during the year and which describes the infectious diseases and common ailments of sheep and gives methods of treatment and control.

DISEASES OF POULTRY.

Coccidiosis was extremely prevalent in young chicks during the past spring and caused heavy losses to poultry raisers. Many cases were forwarded to the laboratory for diagnosis, and numerous letters were received requesting methods of treatment. Crude catechu dissolved in the drinking water, one-third of a teaspoonful of catechu to the gallon of water, proved effective in stopping outbreaks of the disease.

Avian tuberculosis is widely distributed over the United States, and is so extensive in the North and West that the poultry industry is suffering serious losses. Farmers' Bulletin 1200, "Tuberculosis of Fowls," which gives information on the nature and control of this disease, was issued during the year.

A fowl forwarded to the laboratory for examination showed a well-marked case of depluming scabies, a disease which appears to be very rare. Mites of the genus *Epidermoptes* were found in the feather follicles at the ends of the quills.

AUTOPSIES ON WILD ANIMALS.

Ninety-three animals were received from the National Zoological Park for post-mortem examination. Of 50 birds examined, 4 were affected with aspergillosis, 3 with tuberculosis, 3 with septicemia, 6 with coccidiosis, 2 with anemia, 19 with enteritis, 1 with gastritis (impaction of the stomach), 2 with hemorrhage, 1 with wryneck, and 9 with undetermined affections. Of 41 mammals, 4 were affected with tuberculosis, 3 with anemia, 1 with cage paralysis, 1 with colitis, 1 with echinococcus infestation, 7 with enteritis, 1 with gastritis, 5 with gastroenteritis, 2 with hemorrhage, 1 with leukemia, 1 with metritis, 1 with pleurisy and pericarditis, 6 with pneumonia, 1 with pneumoenteritis, 1 with pyemia, 2 with septicemia, 1 with septic peritonitis, 1 with disseminated tumors, and 1 with verminous bronchitis. Of the 2 specimens of reptiles, 1 (rock python) was affected with tuberculosis and pneumonia, and the other with enteritis.

PLANT POISONING OF STOCK.

The investigation of poisonous plants and their effects on live stock has been continued, the major part of the experimental work being done at the experiment station on the Fishlake-Fillmore National Forest, near Salina, Utah, and most of the laboratory work in Washington. A considerable number of plants have been under investigation during the year and the work on some of them is practically complete. Results are published as developments warrant.

BRANCH LABORATORIES.

The branch pathological laboratories at Chicago, Omaha, and Denver continued their work of examining specimens and studying diseases arising in the meat inspection or brought to their attention by veterinarians and stockmen in their respective areas. Special attention has been given to post-mortem examinations on cattle which reacted to the tuberculin test.

In one lot of 85 head of western reacting cattle the Chicago laboratory found skin lesions resembling tuberculosis in 55.3 per cent of the animals. In all such cases where a microscopic examination was made, acid-fast bacilli resembling the tubercle bacillus were found. Similar lesions were found in other cases. Numerous bacteriological examinations were made of samples of water from various meatpacking establishments in and near Chicago.

The Omaha laboratory examined 477 specimens, of which 323 were from cattle which had reacted to the tuberculin test. Tuberculosis was found also in swine, goats, and chickens. Among the other diseases investigated was hemorrhagic septicemia, principally in hogs.

The Denver laboratory, besides the routine examination of miscellaneous specimens received from day to day, has studied the so-called "breaks" following vaccination against hog cholera, also sporadic cases resembling forage poisoning or botulinus infection in horses.

BIOCHEMIC DIVISION.

Investigations concerning hog cholera, studies of dips, disinfectants, and insecticides, laboratory research relative to meat products, and the preparation of tuberculin and mallein have been the principal lines of work carried on by the Biochemic Division under Dr. M. Dorset, chief.

HOG-CHOLERA INVESTIGATIONS.

In the preceding annual report mention was made of the fact that chloroform had been found to be a good precipitant for the hemoglobin contained in antihog-cholera defibrinated blood. This reaction has since been studied in detail, and from the results obtained a process for separating the clear and practically colorless serum from old defibrinated blood has been developed. Tests indicate that the clear serum obtained by the process is rendered practically sterile, that the product is potent, and that the loss occurring during the process is comparatively small, not over 10 or 15 per cent of the total antibodies in the defibrinated blood. A paper describing the experimental work and the process in detail has been submitted for publication.

Continuing the work on the effect of various chemical preservatives on serum proteids, it has been developed that formaldehyde causes a greater change in serum proteids than any of the other preservatives studied. This subject is being investigated further.

Other experiments of a varied nature directed toward a chemical study of antihog-cholera serum have been instituted, but none have progressed to such a degree as to warrant a report at this time.

In view of field reports of disease among hogs which have been given the simultaneous inoculation against cholera, particular attention was given to causes of these so-called "breaks" following the immunizing treatment. Results of an experiment indicate that when an active virus is used in conjunction with serum for immunization the dose of the virus may be exceedingly small and yet produce lasting immunity. In two experiments to test a theory held by some persons that the "breaks" were attributable to faulty methods of feeding, the giving of abundant highly nitrogenous feed immediately following inoculation did not result in sickness among the treated pigs.

The occurrence of disease in hogs which have previously been treated by the simultaneous method has led to the commercial production on a large scale of bacterins which are recommended by the producers for preventing and overcoming "breaks," the theory being that the disease in the treated pigs is not due to lack of immunity against hog cholera, but to invasion by certain microorganisms. Efforts have been made to determine in an experimental way the value of bacterins in practice. An extended series of experiments carried out with *Bacillus suipestifer* indicates that immunization with bacterins made from that organism is of very doubtful value. It has been well demonstrated in this experimental work, however, that the filterable virus of hog cholera exerts a remarkably favorable influence on *Bacillus suipestifer*, and it appears that the latter is an important factor in hog diseases, but its exact relation to hog cholera or other diseases of swine is not yet well defined. These problems are being studied further.

DIPS AND DISINFECTANTS.

The laboratory of dips and disinfectants received and examined 121 samples of dips, disinfectants, and related materials.

During the calendar year 1920 there were sent out to inspectors in the field 966 new test outfits for arsenical dips and supplies sufficient to make 564,000 field tests for arsenic, 32 new test outfits for lime-

and-sulphur dips and sufficient supplies to make 20,240 tests, and 13 new outfits for testing nicotin dips and supplies sufficient to make 6,840 tests, a total of 1,011 new test outfits and supplies sufficient to make 591,260 tests.

Work for the improvement of the saponified cresol solution which is largely used as a disinfectant in official work was continued. A final report awaits the necessary bacteriological tests, which are in progress.

In the course of the study of disinfectants it has been observed that very marked variations in disinfecting power of saponified cresol solutions follow the use of different kinds of soap. Since these solutions constitute a very important class of commercial disinfectants which are used extensively in official disinfecting operations, a study has been begun on the general subject of the mode of action of disinfectants, directing attention first of all to the problem of the variation in disinfecting power of the same cresol when combined with different soaps. Studies are also being carried on relative to the wetting or spreading power of dipping baths in use in the field, the idea being to determine the relation of the wetting power and effectiveness and to develop, if possible, dipping baths of greater effectiveness.

Investigations resulting in an improved method for the detection and determination of methyl alcohol in the presence of ethyl alcohol, some improvements in a method for determining quantitatively small amounts of phenol in serums, viruses, and similar organic fluids, and a new method for the determination of phenol in the presence of certain other phenols were reported in papers submitted for publication in technical journals.

RESEARCH WORK ON MEATS AND MEAT PRODUCTS.

Experiments to determine the vitamin content of various animal tissues that may be used as food have been continued. Pigeons have been fed on such organs and tissues as ox and hog heart, kidney, and tongue, ox, hog, and lamb liver, ox and sheep brains, ox and calf blood, calf thymus, etc., and the results have been noted and compared with regard to the content of "vitamin B." Experiments intended to give information concerning the biological value of the proteins from all of the edible tissues and fluids of the ox, hog, and sheep are also under way. The nutritive value is being studied by feeding young rats a ration which consists of certain definite amounts of the protein from various sources, together with all of the other necessary food nutrients except protein.

An extensive series of chemical analyses to determine the proximate composition of the various edible viscera has been made and is being continued. There is also being carried on a series of analyses designed to determine the percentage amounts of the several amino acids in edible viscera. This work is extremely complicated and difficult, but material progress has been made.

TUBERCULIN AND MALLEIN.

The expansion of the work of tuberculosis eradication has necessitated a large increase in the production of tuberculin for testing cattle for tuberculosis. The increasing use of the newer intradermic and ophthalmic methods of testing has been reflected in enormous

increases in the forms of tuberculin used in those tests, while there has been a diminution in the amount of subcutaneous tuberculin. The year's output, which was supplied mostly to bureau inspectors but partly also to State and local officials, was as follows: Subcutaneous tuberculin, 4,329,420 cubic centimeters; intradermic tuberculin, 534,496 cubic centimeters, or approximately 2,672,480 doses; ophthalmic tuberculin, 538,055 disks; making a total of 4,288,835 doses, as compared with a total of 1,549,680 for the preceding year. New technical methods of procedure have been worked out to meet certain difficulties in production.

The quantity of mallein supplied to bureau and to State officials was 102,610 doses, which is a little less than one-half of the production in the preceding year.

COOPERATION WITH INSECTICIDE AND FUNGICIDE BOARD.

Seventy samples of insecticides intended for use on domestic animals were examined for the Insecticide and Fungicide Board, and 51 of them were found to be misbranded.

Some research work in connection with the Insecticide and Fungicide Act has been begun, with the cooperation of the Zoological Division. Experiments on the effect of mixtures of carbon disulphid and carbon tetrachlorid as a remedy for bots and worms in horses have been completed. Further work is being done on the efficacy of various preparations for the treatment of mange, and an effort is being made to develop a treatment for this disease in dogs.

ZOOLOGICAL DIVISION.

The investigation of parasitic diseases of animals and the study, collection, and determination of animal parasites have been continued in the Zoological Division under Dr. B. H. Ransom, chief.

ROUNDWORMS OF SHEEP.

In continuation of the experiments at the bureau farm near Vienna, Va., for the prevention of roundworms in sheep, an experiment was carried out in which all the sheep in the experiment received monthly treatments with 1 per cent bluestone (copper sulphate) solution. Under this system lambs were reared to marketable age without any losses from stomach-worm infestation and at about 4 months of age averaged one-half pound in weight for each day of life. Most of the lambs were seven-eighths and the remainder three-quarters or fifteen-sixteenths grade Southdown. The bluestone treatments had a beneficial effect upon the ewes as well as upon the lambs. They increased 25 per cent in weight and the wool clip increased from an average of 4.26 pounds to 6 pounds per head. Of various methods of controlling stomach worms thus far tried, that of monthly treatments with bluestone solution is the simplest, most effective, and most economical, and promises to be the most generally applicable in actual farm practice.

ROUNDWORMS OF HOGS.

Field experiments in McLean County, Ill., on the control of intestinal roundworms of swine have been continued. A method of rearing pigs to prevent roundworm injury has been devised and subjected to extensive trial and has proved highly successful. It consists in

observing special precautions to prevent infection of young pigs until they are at least 4 months of age, after which they are less likely to become infected and less likely to suffer seriously if they do become infected. About 1,500 pigs born in the autumn of 1920 on 12 different farms and about 4,500 pigs born in the spring of 1921 on 18 different farms have served as the subjects of these experiments during the fiscal year 1921.

From laboratory investigations it has been established that the path of migration of *Ascaris* larvæ from the intestine to the lungs is by way of the circulating blood and lymph, also that some of the larvæ may be returned to the heart from the lungs, and that then they may be carried to various parts of the body in the systemic circulation.

Repeated injections of the fresh body fluid of *Ascaris* subcutaneously into young pigs, using various quantities ranging from one-half to 1 cubic centimeter, and the injections being made at intervals of a few days, were found to have no effect upon the growth of the animal, nor did they affect the blood count. The first, second, and third injections commonly caused pronounced reactions, vomiting, salivation, rapid breathing, dizziness, itching of the skin, and depression, after which the injections had no apparent effect.

TREATMENT AND CONTROL OF EXTERNAL PARASITES.

HOG LICE AND HOG MANGE.

From tests of various lots of processed crude petroleum, or fuel oil, it has been found that many are too heavy for use in the treatment of hogs for external parasites unless they are thinned with some lighter oil. For this purpose so-called distillate has thus far proved the most satisfactory. No definite rule can be given as to the amount that should be added, owing to the great variations in the viscosity of processed crude petroleum and owing to the effect of temperature upon their viscosity, but usually the addition of 15 to 20 per cent of distillate is sufficient. The oil should be thinned sufficiently so that it flows freely from the container at temperatures suitable for treatment. Ordinarily weather colder than 50° F. is not suitable for treatment.

OX WARBLES.

Of various methods of preventive treatment against ox warbles that have been tried, the most effective has been that in which a wading tank is used. Animals thus treated daily with fly repellent and insecticidal mixtures below the hock and knees during the fly season had few if any warbles the following winter, while untreated animals running with them were grossly infested.

MISCELLANEOUS INVESTIGATIONS ON ANIMAL PARASITES.

Carbon tetrachlorid has been found in experiments to be highly efficacious in the removal of hookworms from dogs, also in the removal of ascarids from dogs and the large strongyles from horses. Tests are being made as to its value in the removal of ascarids from swine. If further tests confirm the results of experiments thus far made the cheapness of this drug will render it a highly important addition to the list of anthelmintics used in veterinary and human medicine.

Studies of various treatments for demodectic mange are being made in cooperation with the Insecticide and Fungicide Board, and

various proprietary insecticides, some of which have been recommended by their manufacturers as anthelmintics, have been tested on experimental animals, in cooperation with the same board.

A new species of *Gongylonema*, of importance in meat inspection, has been found in the gullet and tongue of the hog.

Specimens of gapeworms occurring in cattle in Porto Rico have been found to belong to *Syngamus laryngeus* or a closely related species. *Syngamus laryngeus* heretofore has been known only in the Orient. The presence of this or a similar parasite in Porto Rico points to the possibility of its introduction into the United States.

The species of hookworm known as *Uncinaria polaris*, of common occurrence in American foxes, has been found to be identical with the common European dog hookworm, *Uncinaria stenocephala*. In this country the common hookworm of dogs is *Ancylostoma caninum*. As yet *Uncinaria stenocephala*, though common in foxes, has not become established among dogs in the United States.

During the year 519 fecal samples from imported sheep dogs were examined for parasites that might be injurious to live stock. Fifty-six of the dogs were found to harbor species of tapeworms of the genus *Tænia* and were subjected to anthelmintic treatment before release from quarantine.

Work has also been carried on in connection with the strongyle parasites of horses and the adult tapeworms of sheep and cattle.

Publications issued during the year include the portion of the Index-Catalogue of Medical and Veterinary Zoology relating to roundworms (issued from the Hygienic Laboratory, United States Public Health Service, in collaboration) and bulletins or papers relating to parasites and parasitic diseases of sheep, the turkey as a carrier of gapeworms of chickens, effects of pork-curing processes on trichinæ, and the anthelmintic properties of carbon tetrachlorid. Papers were published outside of the department dealing with flukes of the family Heterophyidæ, migration of ascarid larvæ in the host animal, relation of insects to parasitic worms of the vertebrates, oncocerca in cattle, hydatid, filariasis, metazoan parasites of man, parasitic skin diseases of swine, rabbit bots in cats, etc.

DIVISION OF VIRUS-SERUM CONTROL.

The supervision of veterinary viruses, serums, toxins, etc., under the law of 1913 has been continued by the Division of Virus-Serum Control under Dr. D. I. Skidmore, chief. This work consists of the issuance of licenses to establishments manufacturing veterinary biological products for sale in interstate commerce, the inspection of these establishments as to sanitary conditions and methods of production, the supervision of production, the testing of products, and the issuance of permits for the importation of such products from abroad. The object of this supervision is to assure the potency and harmlessness of this class of remedies.

During the year 132 licenses were issued to 91 firms; 7 licenses were terminated and 1 revoked. The terminations were made without prejudice to the establishments, but the revocation of the one license was due to flagrant violations of the department's regulations. Fifty-seven of the licensed establishments produced only antihog-cholera serum and hog-cholera virus, 27 produced other products only, and 7 produced both classes of products. Seventy distinct classes of products were prepared. To supervise these establish-

ments and products the bureau maintained 18 stations and 39 sub-stations in 20 States. Three permits were issued to one importing firm.

The production of antihog-cholera serum amounted to 322,656,488 cubic centimeters, of which 27,040,651 cubic centimeters consisted of clarified serum. There was destroyed as unfit for use 2,118,986 cubic centimeters of hyperimmune blood when collected or before completion and 4,414,875 cubic centimeters of serum after completion or preparation for marketing. The quantity of simultaneous virus produced was 21,141,508 cubic centimeters, of which 203,830 cubic centimeters was clarified. The quantity of simultaneous virus destroyed before completion or at the time of collection was 342,610 cubic centimeters, while 1,036,954 cubic centimeters was destroyed after completion or preparation for marketing. The production of hyperimmunizing virus was 73,449,239 cubic centimeters, of which there was destroyed 4,216,290 cubic centimeters before completion or at the time of collection and 264,771 cubic centimeters after preparation. To determine the potency and purity of the serum and the purity of the virus 5,410 tests of the former and 1,286 of the latter were made. There were inspected and admitted to the premises of licensed establishments for use in the production and testing of serum and virus 202,322 hogs and 2,828 calves, while 96 hogs and 2 calves were rejected. In subsequent operations 11,523 additional hogs were rejected.

During the year 705 subcultures including 1,892 strains of organisms used in the production of licensed products were collected and submitted for laboratory examination. Of the strains, 1,540 were found to be satisfactory and 352 unsatisfactory. Four hundred and eight samples of products were also collected and examined, and 291 were found to be satisfactory, while 117 were unsatisfactory.

The division has cooperated with the Bureau of Chemistry in an effort to prevent the sale of worthless remedies for hog cholera and other swine diseases. Recommendations were made leading to a considerable number of seizures of such so-called "cures."

EXPERIMENT STATION.

The work of the Experiment Station at Bethesda, Md., in charge of Dr. E. C. Schroeder, superintendent, has consisted, as heretofore, mainly of investigations made both independently and in cooperation with other divisions, concerning infectious diseases of domestic animals, and the provision of facilities for other divisions to make studies on animals under normal farm and field conditions.

ABORTION DISEASE.

So-called infectious abortion disease of cattle remained the major subject of study throughout the year. Though no proof has been obtained to show that cattle are attacked by more than one common, widespread, truly infectious kind of disease of which abortions are frequent manifestations, evidence that this is not the only economically important cause of abortions and pathological conditions of the reproductive organs among cattle has increased. Experiments for the further study of the various causes of abortion have been organized and are now in progress.

The Bang abortion bacillus at times attacks hogs, and several strains of the organism derived from aborting hogs have been care-

fully studied. The strains in some minor respects are unlike those commonly derived from cattle, but the number so far studied is not sufficient to justify the conclusion that the observed differences are the rule or are of common occurrence. Special investigations with the atypical strains are in progress, and the subject of abortions among hogs is receiving as much attention as time and means permit.

The increased cost of maintaining experiment animals, without a parallel increase in the amount of money appropriated, has in recent years necessitated the abandonment of a number of unfinished investigations.

TUBERCULOSIS.

A number of questions concerning tuberculosis have received special attention and several addresses and papers on the subject have been prepared and published.

An effort is being made to improve the method now in use for measuring the purity and potency of commercial veterinary tuberculin, but this work has not progressed far enough to warrant a report at the present time.

Investigations were begun some time ago to determine how early after infection with tubercle bacilli cattle react to the tuberculin test. It seems certain that cattle may react 30 days after they have ingested a sufficient number of virulent tubercle bacilli to start tuberculous processes in their bodies. Small experiment animals, artificially infected with tubercle bacilli, show the first sensitiveness to tuberculin in less than 2 weeks, and in their case it rapidly and greatly increases until their death from the disease is imminent.

Some work has been done to determine whether material obtained from tuberculous cattle, such as blood, blood serum, and urine, can be used in making tests for tuberculosis. The results obtained are not encouraging.

A large number of tests made to determine whether or not an injection of tuberculin may sensitize a nontuberculous animal so that it will react with a subsequent injection have shown conclusively that such a development does not occur.

Tests on the occurrence of tubercle bacilli in dairy products were continued. Cream cheese, which was formerly found to be seriously contaminated with bovine tubercle bacilli, is now free from the germs, so far as can be determined from samples purchased on the local market. This indicates that the bureau's previous work has led manufacturers to adopt effective means to prevent contamination. A number of samples of milk contaminated with bovine tubercle bacilli were discovered and the sources of the contamination were found and made harmless.

MISCELLANEOUS WORK.

Several experiments are in progress on the relation of food-accessory substances to immunity against and susceptibility for infectious diseases.

A large number of small experiment animals were raised at a cost much lower than current market values. Various tests were made with pathological material suspected to contain the virus of infectious diseases. Biological products of various kinds were supplied the other laboratories of the bureau. Every available portion of the station's land was kept under intense cultivation to obtain forage for experiment animals.



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REPORT OF CHIEF OF BUREAU OF BIOLOGICAL SURVEY.

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF BIOLOGICAL SURVEY,
Washington, D. C., September 10, 1921.

SIR: I have the honor to transmit herewith a report of the work of the Bureau of Biological Survey for the fiscal year ended June 30, 1921.

Respectfully,

E. W. NELSON,
Chief of Bureau.

Hon. HENRY C. WALLACE,
Secretary of Agriculture.

WORK AND ORGANIZATION OF THE BUREAU.

As in previous years, the work of the Biological Survey has to do with the wild life resources and liabilities of the country. The game and useful nongame mammals and birds form an asset of enormous value, and on the other hand the destructive predatory animals, such as wolves and mountain lions, and the harmful rodents, such as rats of many kinds, prairie dogs, and ground squirrels, coupled with certain birds in part or entirely harmful, form a distinct liability of no mean importance.

To deal with its various problems the bureau is organized under the following divisions:

1. Economic investigations, in charge of Dr. A. K. Fisher. Investigations cover the control of predatory animals and injurious rodents; experiments in fur farming; and the food habits of birds and methods of control of injurious species.

2. Biological investigations, in charge of E. A. Goldman. Conducts investigations of the distribution, habits, and migrations of North American birds; studies the food and other habits and the distribution of mammals; investigates and maps the life zones of the country; and conducts technical laboratory study of both birds and mammals.

3. National game and bird reservations, in charge of H. F. Stone. Administration involves warden patrol service, the building of fences, houses for wardens, and other improvements on reservations, and, on the Elk Refuge, hay farming on a considerable scale.

4. Migratory-bird treaty and Lacey Acts, in charge of G. A. Lawyer. Through a nation-wide warden service, administers the migratory-bird treaty and the Lacey Acts, the latter covering the unlawful interstate commerce in game and the importation of living foreign birds and mammals with a view to preventing the introduction of harmful species.

5. Alaska reindeer and fur bearers, in charge of E. W. Nelson and W. F. Bancroft. Covers investigations of the diseases, parasites, and grazing habits of reindeer; investigations of the grazing possibilities for reindeer and other stock of the Aleutian Islands; and administration of laws for the protection of land fur-bearing animals of Alaska and for the encouragement of fur farming in that Territory.

ECONOMIC INVESTIGATIONS.

Organized cooperative campaigns in most of the States west of the Mississippi River against predatory animals and injurious rodents have been continued vigorously with constantly increased thoroughness, despite a general depression in the farming and live-stock industries. Reduction in the amount of Federal funds available for this work, coupled with the financial condition of States, stockmen, and farmers, resulted in a decrease from the previous year in the amount of money expended in cooperative campaigns to clear Federal, State, and privately owned lands of the animal pests. This restriction in funds was offset in part by some reduction in cost of operations. The demonstrated value of this work, as shown by the large returns on money expended, which is reported by the cooperating farmers and stock growers, is responsible for its remarkable development, its substantial support, and the demand for its extension. During the year a saving of about \$14,000,000 was effected at a cost of \$1,345,220. Review of these operations for the last six years shows an estimated saving of crops and live stock amounting to more than \$74,000,000 at a total cost to the Government, cooperating States, and landowners of about \$6,080,000, an average of approximately \$12 return on each dollar expended. These savings are cumulative, as the elimination of these pests automatically perpetuates the annual saving from the reduction in their depredations.

Progress has been made in research work having to do with the habits of injurious species and methods of combating them effectively and economically, and has resulted in great improvements in processes of preparing special poisons adapted to use in eradication operations.

In fur-farming investigations, marked advance has been made in the study of the causation and treatment of diseases to which black foxes and other fur bearers are subject when reared in captivity, and in feeding, handling, and housing practices favorable to securing good litters and maintaining a healthy and vigorous condition of the stock.

PREDATORY ANIMALS.

When, in 1916, the bureau first began organized operations to reduce the depredations on live stock by wolves, coyotes, and other predatory animals, the losses from this source were estimated at more than \$20,000,000 annually. These operations include carefully planned trapping, shooting, den hunting, and poisoning campaigns covering the grazing States of the West and extending eastward to western Missouri and northern Michigan. The work done is in co-operation with State departments of agriculture, State live-stock commissions, stockmen's associations, and individuals, so that concerted action may be taken to clear large units of Federal, State,

and private lands of these pests. The Forest Service of the Department of Agriculture and the Office of Indian Affairs and the National Park Service of the Department of the Interior also cooperate on lands controlled by them. During the year skilled hunters and trappers, averaging 246 in number, were employed under bureau supervision. Part of these men were paid by the Federal Government and part by cooperating agencies, the latter having contributed \$213,163 to the work.

The skins or scalps turned in by hunters as evidence of animals taken show a total destruction of 27,611 stock-destroying animals. These consisted of 694 timber or gray wolves, 24,234 coyotes, 2,466 bobcats and Canada lynxes, 129 mountain lions, and 88 bears. Exact returns of animals killed in poisoning campaigns are not obtainable, but, judging from the number of dead carcasses found and the marked reduction in the number of coyotes over large areas following poisoning operations, it may be conservatively estimated that from 25,000 to 30,000 coyotes were killed by this means in addition to the number whose skins or scalps were actually taken, making a total of more than 50,000 predatory animals destroyed during the year.

On the accepted basis of reckoning, the value of live stock saved by the destruction of these animals would amount to more than \$3,000,000. The skins which have a market value become the property of the organization or individual paying the hunter's salary. Receipts from skins taken by Federal hunters and sold during the year amounted to \$8,509.54.

The knowledge and experience gained in conducting operations against predatory animals have enabled the bureau to plan and direct the work with constantly increasing effectiveness. Through field investigation and through reports of hunters and stockmen, the inspectors learn in great detail the localities in which losses are most serious and the ranges and numbers of destructive animals in each district. Trapping and poisoning operations are organized according to carefully projected plans. Skilled trappers are detailed to take especially destructive individuals. Some hunters, working with motor cycle or automobile, can travel rapidly from point to point to eliminate unusually destructive animals which are reported by stockmen. Others, located on ranges where large numbers of predatory animals occur, systematically and relentlessly prosecute the campaign with rifle, trap, and poison.

In winter great poisoning campaigns are organized to distribute over the summer ranges the specially prepared and highly effective poisoned baits which have been devised by the bureau experts. These campaigns are launched in the fall as the stock begins to move out to the winter ranges, the flocks and herds being closely followed up to destroy animals trailing them. In spring, as the flocks and herds return to the summer ranges, trappers go ahead to catch any individuals that may have escaped poisoning. In similar fashion the important winter ranges and lambing grounds are being rid of these stock destroyers. In this way stock losses have been practically ended over great areas of the most valuable summer and winter sheep ranges and reduced in others to very small amounts compared with losses which occurred before these operations were organized, and with such losses as continue to occur in

regions which through limitation of funds it has not yet been possible to reach.

The clearly apparent results accomplished and the large savings effected have won the active support and cooperation of stockmen. Typical of the attitude expressed in a great number of letters received from stockmen the following may be quoted:

Your organization has done more in eradicating the wolf and the bobcat than all the other work that has been done here in the last 25 years.

I believe in the different outfits I am interested in we have saved during 1920 in loss of lambs at least 1,000 head. This is 100 head to the band and at \$6 each would be \$6,000. Then we have saved \$2,000 in labor since a smaller number of men were employed on account of not having to watch the sheep so closely.

Every one of the ranchmen in our club is entirely satisfied with the progress that is being made in eradicating the wolves here. During the past three or four years the losses in sheep and goats from wolves had become so heavy that it was unprofitable to raise that class of stock even with the prevailing high prices. It had become necessary to employ more herders at higher prices and to reduce the number of animals in a herd to protect them against the wolves, and even then many were forced to sell their sheep because there was no relief from the wolves in sight. But I am glad to say that since you have taken charge of the situation and sent in a hunter, and the ranchmen saw the headway he was gaining on the wolves, confidence has been restored on the ranches, and at this time, with most of the old wolves caught, a good many flocks are ranging without herders. We were forced to pay amateur trappers \$50 a wolf and at that they were able to catch only the young wolves; the old sly ones were left to raise the new crop for the next year. Your hunter has been especially successful against the old cunning ones, and I am glad to say that he has caught nearly every one of those that have been around here for over five years.

We feel that the task of controlling predatory animals is not of such a nature that it can be handled for specific areas such as States. It is a West-wide job and not one for any State by itself to tackle, and in handling it on a West-wide basis, it is essential that some uniform plan of operation, such as that now in force, be adopted and continued with coordination of efforts and practices in all sections in a uniform manner. This, in our opinion, makes it absolutely essential that some agency having authority much broader than State lines be in charge of the work, an agency which can forget State lines in its prosecution of the work. We feel in this connection that your bureau is the proper agency. The live-stock industry, particularly, is staggering under the burden of many handicaps. It is a fundamentally basic part of the agricultural industry of the Nation, the industry upon which more than any other the future welfare of the Nation depends. It must and should be relieved from every possible handicap if it is to survive without a terrific setback, and among its handicaps are losses from predatory animals.

Stockmen also maintain that inasmuch as they are paying grazing fees on the national forests they should have the protection of predatory-animal hunters thereon at Federal expense. Such grazing allotments on national forests for 1921 in districts where this work is organized provide leased pasturage for 2,322,180 head of cattle and horses, 36,480 swine, and 8,325,205 sheep and goats. Concrete evidence of the faith of the stockmen in this work is afforded by the fact that appropriations made by States where this cooperative work is in progress for the fiscal year 1922 total \$211,700, while in addition the stockmen as individuals and in their organizations are contributing more and more largely toward the employment of hunters to operate under the direction of Biological Survey inspectors.

During the year predatory-animal work has been in progress in the following States:

Arizona.	Missouri.	Oregon.
Arkansas.	Montana.	South Dakota.
California.	Nevada.	Texas.
Colorado.	New Mexico.	Utah.
Idaho.	North Dakota.	Washington.
Michigan.	Oklahoma.	Wyoming.

On appeal of stockmen and State officials an expert was detailed for a short time to give assistance in Missouri and Michigan, where wolves and coyotes were destroying much live stock and game, and in the latter State were practically blocking efforts to utilize the great areas of cut-over lands for stock-raising purposes. The State Legislature of Michigan promptly enacted a measure which will provide from \$35,000 to \$40,000 a year for work organized under direction of a Survey expert. Requests for assistance in controlling losses due to predatory animals were also received from Minnesota, Wisconsin, Indiana, Iowa, and Louisiana, where serious damage from this source was reported. Investigations were begun to learn the conditions in these States and to devise measures for relief.

The practice followed of devoting special effort to the capture of notoriously destructive individuals and packs has resulted in many important kills, among which the following are typical examples:

The "Custer" wolf, mentioned in last year's report as having ranged for six or seven years in the vicinity of Custer, S. Dak., and during that period to have killed \$25,000 worth of cattle, had escaped all efforts of sportsmen and stockmen to effect his capture, despite a bounty of \$500 placed on his head. Early this year he succumbed to the skill and marksmanship of a bureau hunter.

A pack of eight wolves that had inflicted losses aggregating \$20,000 on calves, pigs, and sheep in and around the Arkansas National Forest were all destroyed by a single bureau hunter between October 31 and November 19. In the worst-infested areas of Arkansas wolves take as much as 90 per cent of the calf crop, and pigs can not be raised at all on account of the combined attacks of wolves and bobcats.

In the vicinity of Splitrock, Wyo., a pack of nine wolves, that were killing about \$10,000 worth of cattle each year, was trapped and poisoned.

All of a pack of five wolves that had ranged in the vicinity of Pueblo, Colo., for several years were taken. The last one to fall victim to the skillfully placed traps was an old renegade that had been known for at least 12 years and is reported to have killed \$6,000 worth of cattle on a single ranch, besides making heavy inroads upon others, and during the last six weeks of his life to have destroyed nine yearling cattle.

In the six years that organized cooperative operations have been conducted under the leadership of the bureau not less than 300,000 predatory animals have been destroyed. Large numbers also have been killed by the unorganized work of private trappers stimulated by bounties and the prevailing high prices of furs. A great reduction in fur values during recent months has removed one of the chief incentives of private hunters. Especially vigorous prosecution of the systematic organized operations is therefore essential to prevent a reinfestation of cleared and partly cleared areas from the otherwise unchecked breeding and migration of these animals.

RABIES.

A few cases of rabies, of which coyotes serve as important carriers, have occurred in Nevada and other States within the original area of the great outbreak of this disease, but its spread has been effectually stopped. Where rabies formerly occurred as a highly dangerous and destructive epizootic, it has been reduced to isolated, sporadic cases by the prompt and vigorous measures employed by the bureau in cooperation with State commissions and health officials. Continuance of control measures is required to prevent the disease from again gaining headway in its original territory and spreading disastrously throughout the entire West.

RODENT PESTS.

Increased interest of farmers and stockmen and a more thorough organization in treating Federal, State, and private lands for the eradication of destructive rodents have been manifested during the year. This has resulted from the obvious benefits derived from the concerted drives under the leadership of the bureau specialists and from improved methods. In order that all Federal, State, and local agencies might be united into an effective working force, cooperation has been continued through the States Relations Service with the State extension organizations, including county agents and farm bureaus. State departments of agriculture and other agricultural and live-stock organizations have participated actively. Officials of the Forest Service of the Department of Agriculture, and of the Office of Indian Affairs and the Reclamation Service of the Department of the Interior also have cooperated effectively in localities involving Federal lands under their control. Cooperation with the U. S. Public Health Service and with State and municipal health organizations has been obtained where the directly economic problems merged with considerations of community health, as in bubonic and pneumonic plague, Rocky Mountain spotted fever, and kindred diseases where such agricultural pests as house rats, ground squirrels, and other rodents serve as carriers of disease-producing organisms. When such rodents occur commonly in cities and villages as well as in the adjacent rural sections, such cooperation is essential to a thorough coping with the situation.

The marked success which has attended the work of the bureau in correlating and guiding local organizations and uniting county and State movements into great inter-State organized campaigns for the control of rodent pests has resulted in demands for the extension of such service. The most pressing demands came originally from the Western States, where conspicuous damage to crops and range occurred, due to the larger native rodents, such as prairie dogs, ground squirrels, pocket gophers, and jack rabbits. More recent recognition of the serious losses caused by the introduced house rats and mice and by such small but abundant native species as pine mice and meadow mice has led to urgent appeals from all over the United States for assistance in organizing effective campaigns against these pests, employing the thoroughly tested methods which have been devised through the research work of the bureau.

PRAIRIE DOGS AND GROUND SQUIRRELS.

Organized campaigns against the highly destructive prairie dogs and ground squirrels were continued in the following States:

Arizona.	Nebraska.	Oregon.
California.	Nevada.	South Dakota.
Colorado.	New Mexico.	Utah.
Idaho.	North Dakota.	Washington.
Kansas.	Oklahoma.	Wyoming.
Montana.		

During the year 18,331,861 acres of Federal, State, and private lands were given a first poison treatment, and follow-up work was done on 4,402,662 acres. The bureau assumes the cost of operations on Federal lands, the State officials on State lands, and the farmers and stockmen pay the cost of work on their holdings. Cooperative funds contributed through State and county appropriations and funds expended by landowners amounted to \$725,000. Poisoned grain prepared and distributed under supervision of the bureau amounted to 1,235 tons, and 104,523 farmers and stockmen took part in the work. Taking into consideration prevailing prices of farm and range products, a saving was effected estimated at more than \$11,000,000. A total of 7,714,518 acres of Federal lands and 70,113,271 acres of State and private lands have been treated and largely cleared of these rodents up to the close of the fiscal year. The estimated value of crops and range grasses saved since the work was undertaken on a large scale in 1916 totals over \$54,000,000.

Information from the Forest Service shows that as a direct result of this work, large areas of national forest land treated for the eradication of prairie dogs now carry 10 per cent more cattle and sheep with a corresponding increase in grazing fees. Stockmen who range their stock upon national forests where prairie dogs and ground squirrels have been destroyed are greatly pleased by the increased pastureage thus afforded as well as by the fact that this prevents their private holdings, when cleared of these pests, from being constantly reinfested by animals coming over from adjacent Government lands.

Through the cooperative plan of work great units of land, involving hundreds of thousands of acres each and previously heavily infested, have been cleared to a point where only an occasional animal can be seen; grass is growing luxuriantly on areas formerly largely or entirely denuded; and good crops are being produced where cropping was not attempted or where crops planted were entirely destroyed by pests. One farmer writes, "I have corn on the prairie-dog town this year as good as any I have seen. It is the first crop ever raised on this ground." The prairie dogs were destroyed during the spring. Another states, "From the bitter experience of previous years I can truthfully say if there had been no poisoning there would have been no crops or grass. Consequently, I consider this work worth the value of my whole crop, or about \$1,000." The manager of a large cattle company writes, "Our entire range has been cleared of prairie dogs and we now consider this once serious question a past issue."

As the eradication campaigns reach a point where these rodents are no longer regarded as a menace, there is a strong tendency for

landowners to neglect complete extermination of the few animals that may remain. Definite effort is being made to have the work continued to completion in order to insure against the rodents again increasing to destructive numbers.

POCKET GOPHERS.

Important work was accomplished in Kansas, Nebraska, Oklahoma, Arizona, New Mexico, Idaho, Oregon, and Washington by demonstrating effective methods of combating pocket gophers and organizing campaigns to destroy them. Vigorous poisoning operations have been conducted in the great alfalfa-producing sections, where these animals cause damage commonly amounting to \$2 or more an acre and frequently destroy the entire stand by cutting off the tap roots. Damage to harvesting machinery by the mounds of dirt thrown up is also a serious item of trouble and expense.

The protection of root crops and citrus orchards has been an important feature of the work of the year. In the irrigated citrus belt of the Salt River Valley in the vicinity of Phoenix, Ariz., and Yuma Valley, many thousands of dollars worth of trees were saved by organized campaigns against these pests. One orchardist writes, "Through continual use of poisoned grain and traps I have succeeded in keeping my 14-acre orange grove free of pocket gophers. Have not lost a tree since you started this work but others near me who have not cooperated have experienced a great deal of damage."

Among the most serious damage by these animals is that due to their burrowing in the banks of irrigation ditches, causing washouts and thus flooding and destroying crops with a consequent great loss of water and expense for repairs; in irrigated lands the burrows also divert the water, preventing its proper distribution to the growing crop. Such losses in the vicinity of the Elephant Butte Dam, in Dona Ana County, N. Mex., are typical of those prevailing widely in irrigated districts. Here pocket gophers caused seepage damage estimated at \$60,000 a year. Irrigation farmers appealed for practical help and organized and provided funds to undertake the work under direction of a bureau specialist. Workmen who patrolled the banks would set strings of 50 traps at short intervals and, returning a little later, would commonly find pocket gophers in two-thirds of them. Where the ground was level, poisoned baits were placed in their holes. A careful survey taken during the spring indicated that 95 per cent of the pocket gophers had been destroyed in this brief intensive campaign, practically eliminating this \$60,000 annual damage at a total cost to the farmers of about \$3,500.

JACK RABBITS AND COTTONTAILS.

Campaigns for the destruction of jack rabbits were continued on a considerable scale in Idaho, Oregon, Washington, Nevada, Utah, and Arizona, being organized along cooperative lines under the leadership of the bureau. Damage was serious to alfalfa, cotton, hay, cantaloupe, lettuce, and other crops produced in the semiarid and irrigated regions. Jack rabbits sometimes occur in enormous numbers in sagebrush areas and cottontails are very plentiful. When feed becomes scarce, due to drought, they congregate about alfalfa,

wheat, and other growing crops, often clearing a field as clean as though it had been done with a mower. In winter when heavy snowfall occurs jack rabbits congregate about stacks of hay or grain, often completely undermining and destroying them. In one community in Arizona where rabbits last year destroyed \$40,000 worth of long staple cotton, no losses occurred this year, due to effective rabbit drives organized in November in which over 300 persons took part. A farmer at Casa Grande writes, "Your poison saved my \$1,000 cantaloupe crop from rabbits this year, and I know its value because I lost my cotton crop last year from rabbits."

In Lincoln County, Idaho, 168,166 jack rabbits (by actual count) were killed by the use of 845 ounces of strychnine applied to suitable bait. In other counties as many as 50,000 jack rabbits were killed by means of organized drives. In spite of unfavorable winter weather conditions for the poisoning campaigns planned in Oregon, 25,000 jack rabbits were killed and counted besides many others that were not found.

Damage to orchards, vineyards, gardens, and truck crops by cottontails was reported from many points throughout the Eastern and Southern States and practical methods of procedure were recommended.

MICE, WOOD RATS, COTTON RATS, AND KANGAROO RATS.

The less conspicuous but exceedingly abundant and widely distributed smaller rodents caused considerable losses locally throughout their respective ranges. Meadow mice and pine mice did much damage in orchards, gardens, and truck farms. Pine mice live mainly in underground tunnels and their destructive activities are usually not observed until irreparable injury has been done; they are probably the most destructive native animal pest in the Eastern States, witness their killing of 1,000 18-year-old apple trees as recently reported from a single orchard in West Virginia. Such trees are commonly valued at \$50 each, and losses of this kind are constantly occurring. They are especially serious as the mice destroy during the productive period the results of long-time investments and cultivation. Damage to potatoes, bulbs, and root crops is also extensive.

Kangaroo rats, which occur in large numbers in sandy regions of the Southwest, interfering with natural reseeding of range areas by destroying great quantities of the seed of native forage grasses and by making frequent raids on fields of sprouting grain, greatly reduce the stand and the value of the crop harvested. Considerable assistance has been rendered in the control of these animals through demonstrations and advising as to practical procedure in combating them.

BEAVERS AND WOODCHUCKS.

The beaver, which has been protected because of its value as a fur bearer, has become an intolerable nuisance in some localities by damming streams and flooding valuable meadows and cultivated lands, cutting orchard and shade trees even in the farmer's dooryard, diverting natural watercourses through tunneling in creek banks, and by feeding upon and trampling down growing grain crops and

alfalfa. In cooperation with State game officials demonstrations were given as to methods of capturing these animals alive and transporting them to national parks or other places where they are welcome.

Demonstrations and advisory assistance were also given as required in preventing damage by mountain beavers in Oregon and Washington, and in destroying woodchucks in localities throughout the country where they were proving destructive to alfalfa, clover, and other field and garden crops.

HOUSE RATS AND MICE.

House rats, the most destructive mammal pest in the world, each year destroy food and other products in field, granary, warehouse, store, and home to the extent of more than \$200,000,000, a sum equaling the economic output of 200,000 men working continuously. In addition to their destruction of food products, poultry, and other agricultural property, these pests are carriers of bubonic and pneumonic plague and other diseases communicable to man, and of trichinosis in swine; and since rats and mice may contract avian tuberculosis, both may have an influence on the spread of this infectious disease among domestic poultry.

The educational campaign has been continued to acquaint the public with the economic losses and menace to health due to the presence and destructiveness of these pests. Increased interest in effective measures to combat rats is manifest throughout the country, and the bureau has furnished to individuals and extensive State organizations practical, tested methods of poisoning and trapping them and effective means of excluding them from buildings by rat-proof construction. Emphasis has been placed on means of cutting off their food supply and eliminating favorable rat harborage. Wherever health questions have been directly involved, cooperation of Federal, State, and local health officers has been obtained. The economic work of the bureau in aiding in the destruction and exclusion of these pests at all times has an important, indirect effect upon the public health by reducing the numbers of these potential carriers of disease and by bringing about more sanitary conditions through the emphasis placed on proper disposal of garbage and other refuse.

Losses from rats have doubtless been exceptionally heavy during the past year because of the unusually large quantity of grain and other agricultural products that have been left in shocks in the fields, or kept in stacks and farm buildings, and in elevators and warehouses. The good shelter and the abundance of food thus afforded have given rats and mice opportunity to multiply rapidly.

There has resulted a constantly growing demand upon the bureau to provide skilled leaders to coordinate and direct the work of local organizations. Responding to an appeal from 20 organizations in Texas, following a series of local and State meetings, an experienced man was provided the latter part of January to head the work. Effort was concentrated on organized procedure. Campaigns were launched in counties where suitable organization could be effected, and as a result 670,000 rats, by actual count, were destroyed in about four months at a cost of less than \$2,000 to the cooperators. Denton County conducted the most successful campaign, taking 253,000 rats

in six weeks. As the number of people living in this county is only 35,000, this catch is of interest as showing the ratio that may exist between the human and rat population. A two-weeks' campaign in another county netted 70,000 rats. In many other States, notably North Dakota, Oklahoma, New Mexico, Kansas, Nebraska, Oregon, and Washington, similarly organized work has been conducted under the leadership of experienced bureau representatives.

MOLES.

Many complaints of damage by moles to lawns, gardens, and field crops have been received, and in all such cases information as to practical methods of combating moles has been furnished through correspondence, published material, or demonstration.

PRODUCTION OF DOMESTIC RABBITS.

Interest in the production of domestic rabbits as a source of meat and fur has continued to develop in the United States, and the bureau has kept in close touch with leading rabbit producers and officials of State organizations of rabbit breeders. Information has been furnished regarding the care and management of rabbits, and, in cooperation with the Bureau of Markets, regarding practical procedure in developing a satisfactory market. Study of the diseases to which domestic rabbits are subject has been continued in testing the value of serums and bacterins in preventing or curing infectious diseases of these animals.

FUR-BEARING ANIMALS.

For centuries fur products have been an important factor in world trade and efforts to open up new sources of supply in America were the stimulus for important exploring expeditions which increased national territorial possessions. The fur trade, which was the forerunner of agricultural and other industrial developments, has now become one of the large and important industries in the business world, providing employment for thousands of skilled and unskilled workers and contributing to the comfort of people who wear fur garments. North America has been the leading continent in the natural production of furs and is also the greatest fur consuming region in the world. Imports of undressed furs into the United States during 1920 were valued at over \$84,400,000, and of dressed furs and manufactured garments in which furs are used, at \$9,131,000. Members of the national organization of fur dressers and dyers dressed during 1920 furs valued at \$52,910,589. The revenue derived by the Federal Government from import duties on articles made of fur amounted to \$15,311,214 in 1920. Exports of furs and manufactures thereof for this period were valued at \$32,886,995. The approximate turnover in the fur industry of the United States during 1920 was \$352,000,000.

Because of the enormous drain upon the natural source of supply, the maintenance and stability of the fur business is dependent upon a far-sighted, constructive program of conservation of native fur bearers and upon the propagation of certain kinds in captivity or

under control. Within a few years in the United States and Canada a growing industry has developed in rearing silver, black, and cross foxes. In a survey made during the spring of 1921 there were reported to be 340 fox ranchers in the United States having 4,350 breeding animals, their stock and equipment being valued at more than \$4,280,000. The total number of breeding foxes in the United States will be materially increased by the young of the spring of 1921 which were not reported. Fox ranches were reported in the following States:

California.	Michigan.	Oregon.
Colorado.	Minnesota.	Pennsylvania.
Idaho.	Montana.	Virginia.
Illinois.	New Hampshire.	Washington.
Maine.	New York.	Wisconsin.
Massachusetts.	Ohio.	

A considerable number of people are also rearing skunks, raccoons, minks, muskrats, opossums, and beavers.

The bureau has continued its investigations designed to aid the development of the fur industry. These have included the study of the feeding, breeding, and management practices followed by those engaged in the business, and laboratory and other investigations at the Experimental Fur Farm, near Keeseeville, N. Y. Important progress has been made in determining feeds suitable for maintaining health, growth, and reproduction among foxes, and in obtaining data regarding the physiology of these and of other fur bearers, such as the normal pulse and respiration rate, which are required as a basis for the detection and diagnosis of disease. Valuable information has been obtained regarding breeding periods, and the causes of mortality and the early growth and development of the young.

The most notable advance has been made in the investigation of diseases to which fur bearers, especially foxes, are subject; the conditions of pens and surroundings favoring contraction and dissemination of such diseases, and sanitary measures essential to their prevention; also in the determination of safe and effective remedies, dosage, and methods of administration in cases of disease.

Observations made indicate that the hookworm is one of the most serious parasites that fox ranchers have to contend with and that its occurrence is far more widespread than has heretofore been realized. The unexplained death of many foxes has unquestionably been due directly or indirectly to such infestation. Losses from this parasitic disease are not limited to death and impaired health of foxes but are measured also by reduced commercial value of the pelt produced and by lowered breeding capacity. There is little superficial evidence of light hookworm infestation either in appearance of health or quality of pelt. Foxes so infested, however, are a constant source of danger, for if kept in undesirable types of pens they will eventually acquire heavy infestation and be at all times a means of carrying infestation to all other pens and foxes on a ranch. This feature is brought to the serious attention of all fox ranchers and particularly those who are so fortunate as to have stock free of hookworms or are starting out with a new set of pens and foxes. With the view of bringing this feature forcefully to the attention of breeders and affording them much-needed protection, the department recently promulgated quarantine orders governing importation into the United States of

animals that are or may be infested with these parasites or are affected by other communicable diseases of parasitic or bacterial origin.

Especial emphasis is placed upon the careful selection of healthy, vigorous stock having high-pelt quality combined with good fertility and dependable breeding record. That certain breeding strains will prove of higher pelt quality and be more prolific than others is evident. As in other lines of live-stock production, the largest measure of success will be attained by judicious selection of breeding stock, proper sanitation, regularity and skill in feeding, and the adoption of other good-management practices.

A discussion of the fur bearers and of fur farming in Alaska is contained in the information on that Territory at the end of this report.

ECONOMIC ORNITHOLOGY.

Bird protection has been long established in the United States, and responding to it, certain species of birds are becoming overabundant from an economic point of view. In some cases changes in feeding habits or simply the multiplication of normal feeding effects due to increased numbers, have drawn attention in an emphatic way to a neglected aspect of economic ornithology, namely, the damage done by birds and the means of controlling it.

ROBINS.

In the last few annual reports mention has been made of investigations of depredations by birds protected by the migratory-bird treaty act and of orders of the Secretary of Agriculture permitting the destruction of certain birds when actually doing damage. During the fiscal year covered by this report investigations of the relation of robins to small fruits were extended to Indiana, Michigan, and Oregon. There is no question that robins are much more abundant than formerly and that they have been taking a heavy toll of small fruits, in many cases all of small crops; these depredations were intensified during the latter part of the year by a drought which reduced the supply of wild fruits. As a result, therefore, of special and general investigations of the food habits of the robin, and after consultation with State authorities to learn their attitude in the matter, an order was issued by the Secretary authorizing land-holders and their bona fide agents in the States of New Hampshire, New York, Indiana, Wisconsin, Minnesota, and Oregon to kill robins by shooting when these birds are actually damaging small fruits.

DAMAGE BY OTHER BIRDS.

During the year the only order modifying the protected status of a bird under the migratory-bird treaty act was that issued in the case of the robin, but investigations were made of damage by other species, and it was found necessary to continue them in the hope of reaching satisfactory findings. These studies included investigations of damage by wild ducks and blackbirds to grain crops in the Imperial Valley, California, and by crows, chiefly to grain crops in Oregon and Oklahoma. In the case of the crow, work was carried to the stage of experiments in methods of control. In Oklahoma.

especially, the numbers of crows have increased greatly in recent years and their winter concentration in that State has resulted in great losses in grain. Progress was made in developing an efficient, slow-acting, poisonous bait. Such a bait seems essential in crow-control work because of the extreme wariness of this bird and its reluctance to continue feeding in a given area once it has become alarmed. It is of interest that a slow-acting bait is required for crows while greatest efficiency in poisoning mammal pests has been obtained by the most rapidly acting poisons. It is doubtful whether effective measures for the control of crows can be carried out during the fall and early winter when there is an abundance of food, but it is believed that successful control campaigns can be conducted in periods of severe winter weather. Work will be continued at that season during the coming fiscal year.

SURVEYS OF PLANT LIFE IN WILD-FOWL RESORTS.

Investigation of plant life on the feeding grounds of wild fowl was confined practically to the State of Missouri, a single hunting preserve in Illinois also being visited. About 250 lakes and ponds in Missouri were surveyed and a report upon them prepared for publication, which discusses in detail the present status of wild-fowl feeding places in the State and means of their improvement.

BIRDS IN RELATION TO INSECT PESTS.

In the course of spring and fall trips to Massachusetts, an effort was made to learn the relation of birds to the European corn borer, a comparatively recent importation which is rapidly developing into a most serious pest. These borers live in concealment during practically all the larval stage, and it was found that birds are either not adapted for feeding upon them or have not yet learned to find them. Only two species of birds were found to prey upon this pest, and both of them, like the insect, are introduced—the ring-necked pheasant and the starling.

In another case, however, it was found that native birds were doing good work against an introduced pest, the Japanese beetle, in New Jersey. The investigation of this case, begun the previous year, was completed. Birds were collected over the beetle-infested area through the period of adult existence of the insect, and field observations and stomach examinations show that birds play an important role in combating it. Thirty-one species of birds were collected, and the majority had fed upon Japanese beetles. The most important bird enemy proved to be the purple grackle; examination of the stomach content of all these birds which were collected showed the presence of these beetles, to an average extent of two-thirds of the total food. Other birds of importance as enemies of the Japanese beetle, and the percentage of beetles taken were: Meadowlark, 50.7; starling, 42.3; cardinal, 38.6; catbird, 14.8. Toads also eat the Japanese beetle, and in the specimens collected this beetle made up 22 per cent of the total stomach content.

Because birds were suspected of having an entirely different relation to a pest, namely, that of aiding in its spread, an investigation

was made at the request of the office of Cereal Investigations of the Bureau of Plant Industry of English sparrows as possible distributors of the wheat-gall nematode. The results indicate that when the sparrows are feeding on green galls only a very small proportion of the nematode larvae pass through the alimentary canal alive, and that these birds must be considered only a minor agent in the distribution of this nematode. During the early development of these galls English sparrows seem to have a special liking for them. At first it was suspected that these sparrows might spread the infestation in this way, but it was found that their active digestion sufficed to kill nearly all of the nematodes.

MISCELLANEOUS WORK ON THE FOOD HABITS OF BIRDS.

Laboratory study of the food habits of various groups of birds was carried on more effectively than ever, a larger number of stomachs being examined than in any previous year. Work was completed on the canvas-back, redhead, ring-necked, and scaup ducks, and work was begun on preparation of a report for publication. Examination of the stomachs of English sparrows, looking forward to a modern and thorough study of the birds' economic status, was continued. Nearly half of the more than 8,000 stomachs now on hand have been examined. The contents of nearly 600 stomachs of hawks and owls also were studied during the year, clearing up accumulations of hawk stomachs to date. Analyses were completed also of a number of shorebirds, including the willet, dowitchers, robin, snipe, and godwits. As in previous years examination of special collections for correspondents was conducted; a consignment of stomachs of nighthawks and pigmy owls from Oregon may be mentioned in this connection, and one of merganser stomachs from the Miramichi and other rivers in New Brunswick; examination of the latter indicates serious destruction of trout by mergansers of the region.

FOOD HABITS OF OTHER ANIMALS.

For many years the facilities of the stomach analysis laboratory and the experience of the analysts have been utilized incidentally to develop exact information on the food habits of various vertebrates other than birds. At the beginning of the year a definite project was established for the first time for the study of the economic relations of two of these groups—reptiles and amphibians. There is no question that through their destruction of insects these animals have a relation to agriculture concerning which we should have precise information as a guide to their rational treatment, for it need hardly be stated that public policy toward these animals in the past has been anything but rational.

The main accomplishment under this new project was the removal of the contents of approximately 2,400 stomachs of toads from specimens in museum collections. Nearly 2,000 of these were obtained from specimens in the United States National Museum and the remainder were presented by the University Museum, Ann Arbor, Mich., and the zoological department of the University of Wisconsin. Actual examination of the stomachs has been in progress for two months.

As an aid in replying to correspondence, two mimeographed forms have been prepared, one on the care of the American chameleon and the other on North American venomous snakes. The latter is a résumé of the subject, intended primarily to correct fallacies in popular beliefs and to have available in brief form the pertinent facts relating to these snakes; it covers such topics as poisons, poison apparatus, treatment, mortality, shedding of fangs, rattles, food habits, suggestions for destruction of the reptiles, snakes swallowing young, number of young and habits, and a key to venomous snakes.

The collections of both examined and unexamined mammal stomachs were thoroughly reorganized and catalogued, the collection of stomach analysis cards put in order, and a considerable number of new stomach examinations made. Among the latter were a number of Alaskan reindeer and mountain sheep. Considerable direct information on the forage of these animals was thus obtained which was desired in connection with investigations of the reindeer industry and of the food of game animals now being made by the bureau.

BIOLOGICAL INVESTIGATIONS.

Although the biological surveys of States have been somewhat curtailed during this year, notable progress has been made in several other directions. In general the activities of this division have continued along the lines previously followed, especially those which have proved to be of value in relation to various well-established duties with which the bureau is charged, such as the enforcement of the migratory-bird treaty act, the Lacey Act, the administration of mammal and bird reservations, the conservation of game birds and mammals, and those bearing upon the relations of birds and mammals to agriculture, stock raising, and forestry. The extent and value of the various files and card indexes on the distribution, abundance, and habits of North American birds and mammals, particularly regarding life histories, which have such an intimate and complex relation to the welfare of man, have continued to grow. These information files become increasingly useful from year to year and enable the bureau to respond satisfactorily to inquiries continually being received from individuals, scientific institutions, and State and Federal officials throughout the United States, as well as from foreign countries.

BIOLOGICAL SURVEYS OF STATES.

Field survey work was conducted in Washington and Wisconsin only, being necessarily confined through lack of funds to those States in which cooperative arrangements with State institutions were in effect.

In Washington a field party made an exploratory trip across the Cascade Mountains just south of the Canadian boundary from Glacier, Whatcom County, to Loomis, Okanogan County, which resulted in the acquisition of considerable valuable data on the fauna of this interesting and little-known region. Representatives of the State College of Washington and of the Bellingham State Normal School cooperated with the Survey party in this work, which continued from early in July to the end of September. During the

remainder of the year a representative of the bureau was engaged in similar work in various parts of the State, mainly in the northern and western counties.

In Wisconsin the field survey continued from July 1 to the middle of September, mainly in the southwestern part of the State. The Wisconsin Geological and Natural History Survey cooperated in this work, keeping one man in the field, under the direction of the bureau, during the entire period. Notable progress was thus made in the study of the distribution of birds and mammals within the State.

Reports based on field work of the survey completed, but not published, include "Mammals of New Mexico," "Mammals of North Dakota," "Mammals of Wyoming," "Birds of Alabama," "Birds of New Mexico," and "Birds of Texas." "A Biological Survey of Alabama," consisting of a report on the life zones and an annotated list of the mammals, is in press and will shortly appear as North American Fauna, No. 45. Progress has been made during the year in technical studies of mammals, especially the shrews and chipmunks.

DISTRIBUTION AND MIGRATION OF BIRDS.

Work on bird migration has progressed essentially the same as during previous years. Reports from about 275 observers were received, an increase over the number sent in last year. Progress has been made in abstracting records from published sources, in identifying, carding, and arranging specimens of birds lately obtained, and in copying the field notes of various members of the Survey. The number of record cards now in the bird files covering habits, distribution, and migration is nearly 1,450,000.

No general reports on migration have been issued during the year, but the following are practically completed: "Distribution and Migration of North American Terns and Their Allies," and "Distribution and Migration of North American Grebes, Loons, and Auks."

BIRD COUNTS.

Manuscript reports from the seventh annual series of bird counts received during the year numbered about 50, a substantial increase over the preceding year, a result of special efforts to reenlist the services of many of the collaborators whose work was interrupted by the war. Fortunately many of these reports were made on the same areas as in previous years, and thus will give continuity to an interesting and valuable series of observations that it is hoped will be maintained through a long period in order to establish facts as to average as well as varying conditions governing bird life in such areas. A third report on bird counts in the United States, covering the years that have elapsed since the second report, is being prepared.

BIRD BANDING.

The work of banding birds taken over by the bureau last year has been organized and the operations extended. At the close of the year the cooperators enlisted in the undertaking numbered 135, and this

number is steadily increasing as the work becomes better known and its value more appreciated. Accomplishments during the year included both the systematic trapping and banding of land birds and the banding of nestlings, as well as the banding of waterfowl, for the purpose of obtaining information concerning the migration of birds which is of special value in connection with the administration of the migratory-bird treaty act. Various State organizations, including State game commissions, are cooperating in this investigation. The number of birds banded under the direction of the bureau during the year was 2,845, and much valuable information was gathered from reports of "return" records (banded birds which were recaptured), in some cases at a point far distant from that where they were banded. Plans for the summer of 1921 contemplate the marking of waterfowl on their breeding grounds in North Dakota, and later it is hoped to extend operations to some of the more notable wintering grounds in the Southern States. One publication was issued during the year, a circular of instructions for bird banding.

INVESTIGATIONS OF MIGRATORY WILD FOWL.

Investigations of migratory wild fowl have been carried on by members of the Survey and in cooperation with State game officers and others.

The field party, headed by an assistant of the bureau, which was engaged at the close of the last fiscal year in studying ducks and other migratory game birds on their breeding grounds on the delta of the Athabasca River in central Canada, continued these studies until the departure of the bulk of the birds for the south early in October. This expedition resulted in the accumulation of a great quantity of very useful information on the breeding and migration of these valuable birds on one of the most extensive and important areas to which they resort, both during the nesting season and while on their seasonal journeys north and south.

Near the close of the last fiscal year an assistant of the Survey proceeded to southern South America to study the conditions governing the abundance of certain North American shorebirds which resort to that region to escape our winter. These investigations were undertaken in response to a demand for definite information regarding the status of these birds as affected by settlement in remote regions of the Southern Hemisphere, and its bearing on their lessening abundance in this country; also to provide data for the formulation of provisions of possible treaties which may be negotiated with countries lying south of the United States—treaties similar in character and object to that now in effect between our country and Great Britain, by which much-needed protection is given these valuable birds in the United States and Canada.

Our representative, who completed his studies and returned late in May, 1921, was very successful, having visited some of the more important areas most frequented by wild fowl in parts of Argentina, Paraguay, Uruguay, and Chile, and secured a mass of first-hand data of great interest. Besides the value of this information in relation to problems of conservation in this country, it will be of material assistance in formulating agreements to insure the most beneficial results in case migratory-bird treaties are consummated with any

South American country. In addition to the data secured on migratory shorebirds, it was found that some of our commoner insectivorous birds winter in those southern countries in considerable numbers. A report on the results of this very important expedition, the first of its kind in South America, is in course of preparation.

WILD LIFE IN NATIONAL PARKS AND NATIONAL FORESTS.

In the early part of July an investigation of the conditions affecting elk on the Sitgreaves National Forest, Ariz., the descendants of a small herd brought from the Yellowstone National Park, was made by an assistant of the bureau, in cooperation with the Forest Service.

The elk, though widely scattered at this season, were found to be thriving. On the basis of various conditions bearing on the matter, carefully studied on the ground, boundaries for a proposed State game refuge were agreed upon which it is believed will admit of a considerable increase in the elk herd and other game without interfering with present arrangements relative to the grazing of domestic stock. The recommendations resulting from this work were submitted to the Governor of Arizona, who has expressed his approval of the plan and his desire to have the State elk refuge established as early as may be practicable.

The 1921 edition of the circulars of information concerning Yellowstone National Park and the Mount Rainier National Park, published in the spring of 1921, contain revised lists of the mammals and birds of these public recreation areas, contributed in part by naturalists of the Biological Survey. In addition, a more comprehensive treatise on the mammals of the Yellowstone National Park and a similar work on Mount Rainier National Park, the latter comprising the results of field studies of the life zones and extensively annotated lists of the birds and mammals, both by assistants of the bureau, are in the hands of the National Park Service for publication.

LIFE HABITS OF INJURIOUS ANIMALS.

During the year an assistant has been continuously engaged in studying the life habits of mammals, with special reference to the food habits of injurious rodents and their general relations to agriculture, grazing, and forestry, in North Dakota, Montana, Idaho, Oregon, California, and Arizona. In Minnesota and Wisconsin studies of beavers and muskrats were made to supply needed information in relation to rearing these animals on fur farms.

Field practice includes the observation of living animals under normal conditions, the excavation of burrows and dens to ascertain methods of storage and the kind of food preferred, observation and feeding of captive individuals, stomach examination of specimens taken under normal conditions, and studies of breeding habits. Studies in North Dakota were confined mainly to the two species of ground squirrel common there. In parts of the State the few thirteen-lined ground squirrels which had reinfested certain territory recently cleared of them were found to be feeding almost exclusively on the swarms of grasshoppers then doing extensive damage. Work in Oregon involved studies of such injurious rodents as ground squirrels, pocket gophers, rabbits, kangaroo rats, and pocket

mice. In Arizona about six months, including the winter season, were spent in studying the food habits of rodents, with special reference to their effect on native forage on stock ranges. Work in other States included the investigation of special problems—in the Bitterroot Valley, of the Columbia ground squirrel; in Idaho, of certain pocket gophers; and in California, of the wood rats.

The more information that is obtained concerning the habits of our native rodents, the more closely they are found to be related to the prevailing plant life. This gives these individually unimportant but enormously numerous animals a little-suspected although in the aggregate a very great economic importance. The occupation of the country for farming and other purposes has very generally destroyed the original checks and balances which held our wild birds and mammals at a more or less safe level as to numbers. The result is that without learning their habits and devising and enforcing methods for their control a number of species of predatory animals and rodents and even some birds would multiply until in considerable areas successful stock growing and agriculture would be carried on under severe handicaps and might be impossible.

GAME AND BIRD RESERVATIONS.

This has been one of the most successful years in the history of the Federal bird reservations. The increase of big game has been extremely satisfactory and no damage to the reservations or losses of moment have occurred. A small fire starting in the grass on the Montana National Bison Range, which might have developed into a serious menace, was promptly extinguished. The public is much interested in the reservations and is more and more respecting these wild life sanctuaries. Improvements have been made in various places by growing grain and cover for the use of birds, by the erection of new and the improvement of old buildings, and by the provision of new fences, signs, boundary marks, and added facilities for motor transportation. As a result of several extended inspection trips, during which most of the reservations were visited, the assistant in charge was able to suggest a number of improvements in administration which will undoubtedly be of much benefit. In addition, he represented the bureau at the national parks conference at Des Moines, Iowa, January 10 to 12, and inspected and reported upon a proposed migratory wild-fowl refuge and public shooting ground on the Bear River marshes, Utah.

Investigation of Federal bird reservations during the year developed the fact that the reservations covering irrigation reservoirs at East Park, Calif.; Keechelus, Kachess, Clealum, and Bumping Lake, Wash.; and Loch Katrine, Wyo., lack plant food and other requirements for useful bird reservations and are comparatively little visited by wild fowl. Recommendation was made accordingly and, by Executive order dated May 20, the President eliminated them from the list, and also San Francisco Bay Reservation, California, which is no longer useful as a bird reservation. This reduced the number of game and bird reservations under control of the Biological Survey from 74 to 67, but on June 30, 1921, the number was 70, the following three having been added during the year: Caloosahatchie, Fla., and Nine-Pipe and Pablo, Mont. Five of these are

fenced big-game reservations, three of which were also made bird reservations in order better to protect the wild bird-life frequenting them.

BIG-GAME PRESERVES.

Big game under fence on reservations controlled by the bureau, including buffalo, elk, antelope, and deer, have increased most satisfactorily during the year, particularly the antelope, which have at times suffered serious losses; in fact, at one time it was doubtful whether it would be possible to maintain antelope herds on the Federal game preserves. The critical period, however, appears to have been passed. The following table shows the game animals on inclosed preserves during the last six years:

Kind of game.	1916	1917	1918	1919	1920	1921
Buffalo.....	207	246	302	368	427	508
Elk.....	159	184	212	274	384	504
Antelope.....	40	49	49	54	60	92
Deer, mule.....	3	6	22	29	27	37
Deer, white-tail.....					6	5

For some years coyotes or other predatory animals, and possibly poachers, caused such serious losses among the antelope that their future within the Federal reservations was extremely doubtful. By increased vigilance of the wardens in charge and by detailing skilled predatory-animal hunters to trap and use poison about the reservations, a large number of predatory animals have been destroyed and the death rate among the game much decreased. No violent deaths appear to have occurred among any of the game animals during the year and only the few that might be expected from natural causes. A representative of the Biological Survey and one from the American Bison Society made a reconnaissance during the spring of an extensive unsurveyed area of country in southwestern Idaho to ascertain its value as a proposed antelope and sage-hen reservation. The few stockmen in this area favor such a reservation, which might be established without interfering with the grazing of the number of live stock now located there. This area is one of the few in the West still containing a considerable number of antelope.

National Bison Range, Mont.—This preserve has had a prosperous year. The buffalo have increased from 332 to about 388. One sick buffalo was found and it was necessary to destroy him; there have been only two other deaths. The elk now number 265 as compared with 200 a year ago. There were 45 antelope a year ago, 15 have been born, and none have died, which gives a total of 60 now in this band. The mule deer show about 35 as against 19 a year ago. There is one white-tailed deer on the range. In cooperation with the State, 24 ring-neck pheasants were turned out on the range in September, 1920.

Improvements have been made at the watering places and an unsatisfactory condition relating to an important spring within the reservation has been adjusted.

About 300 posts of the game fence have been replaced with new 10-foot posts. A new water system has been installed at the headquarters as additional fire protection and for domestic uses; this

includes a gasoline pump and water-storage tank. Improvements made on the warden's house include a kitchen extension and various fixtures which add to the comfort of the warden's family.

Wind Cave National Game Preserve, S. Dak.—The buffalo herd has increased from 60 a year ago to 71, the elk from 105 to about 150, the antelope from 20 to about 32, and there are still 2 mule deer. It is particularly gratifying to know that the antelope band has done extremely well, and the warden in charge is to be commended for his successful efforts to prevent losses by constant watchfulness and destruction of coyotes.

Through cooperation with the State wardens, convictions were obtained in the cases of illegal killing of elk in the vicinity of the preserve.

Concrete basins have been built at watering places to prevent the springs being tramped into boggy mudholes.

Niobrara Reservation, Nebr., now has 37 buffalo and 53 elk, as against 28 buffalo and 47 elk a year ago. A new game fence, greatly enlarging the inclosed range, is under construction, all the material for it having been received. The old military buildings have been removed, except those needed for reservation purposes. The State, with the aid of the Bureau of Public Roads, has completed a new road leading from Valentine to and through the reservation, and this should better conditions materially, as in bad weather the old road was frequently impassible.

Sullys Hill Game Preserve, N. Dak.—The six buffalo presented by the Portland City Park have become acclimated and one calf was born in 1919 and two this year, raising this to a herd numbering nine. The elk have increased here until it is desirable to dispose of some, as the preserve has only about 600 acres under fence. In addition to the buffalo and elk there are about three white-tailed deer. No losses have occurred among the animals during the year.

Construction work on the new buildings, roads, and recreation grounds was carried on through the spring, summer, and early autumn, but owing to the difficulty of securing mechanics and other labor and the exhaustion of available funds much yet remains to be done. The women's resthouse is nearly finished, the ornamental iron gates are on hand to be erected, and the new entrance road is ready for surfacing. This preserve continues to be a very popular resort for the people of the surrounding region and the improvements being made will add greatly to the comfort of the visitors.

Elk Refuge, Wyo.—The mild winter of 1920-21 was of great benefit to the elk herds. The southern, or Jackson Hole, herd, which winters south of the Yellowstone Park, suffered severely the winter before when thousands of elk died from starvation despite the fact that hay was bought in great quantities and fed to them in addition to the crop harvested on the refuge. Counts during the winter of 1920-21 show that only about 9,300 elk remained in that region. Approximately 3,500 was the largest number reported from the refuge at one time, as in some places the elk maintained themselves on the range all winter. Not over 75 are reported to have died in the Jackson Hole Valley during the winter and, with the favorable spring and summer which have followed, this herd should have begun to recuperate.

About 375 tons of hay are left over from last winter, and as the prospects point to a good crop this year there should be more than a thousand tons ready for next winter's feeding. A new set of haying machinery has been purchased to replace one of the old sets which became practically useless last summer.

BIRD RESERVATIONS.

During the year considerable progress was made in posting and defining boundaries of many of the bird refuges. This is important, since it facilitates the better guardianship of the refuges, strengthens the Government's cases in instances of violations, and is of particular benefit to sportsmen and others who are interested in maintaining the reservations. Orders have been placed for metal signs of a distinctive design, which will be more durable, easier to post, and cheaper in the end, and in every way an improvement over cloth signs.

The planting of grain to provide food and cover for sharp-tailed grouse and pheasants on the National Bison Range has been continued on a broader scale. The results have been most gratifying in increasing the number of grouse and maintaining both them and the pheasants on the reservation. No disease or unusual loss of birds, nests, or eggs has been reported and the year appears to have been a very favorable one for the birds on practically all the reservations.

An Executive order signed in June enlarges the Indian Key Reservation in Florida by the inclusion of Bush Key and three smaller keys; these are of considerable value to the nesting birds, which are increasing in this vicinity. It is especially notable that considerable numbers of roseate spoonbills are congregating about this reservation. These beautiful birds, among the most interesting and picturesque of all the avian inhabitants of Florida, were nearly exterminated years ago by plume hunters. Under protection they are gradually increasing in numbers and may again become one of the well-known inhabitants of the State.

The bureau for a number of years has been conducting investigations concerning the migratory wild fowl which breed in large numbers on the Bear River marshes near Great Salt Lake, Utah. In order that this splendid resort for wild fowl may be maintained for their benefit, it has been proposed to establish it as a breeding reservation to be utilized in fall as a public shooting ground. It is hoped that this plan may be carried out, since such favorable breeding grounds are becoming exceedingly scarce in the United States. A few interesting facts regarding some of the more important bird refuges follow:

Lake Malheur, Oreg.—In the spring an unusual quantity of water raised the level of Lake Malheur, flooding some of the nests, overflowing into Mud Lake, and partially filling the dry bed of Harney Lake. Migratory wild fowl nested in greater numbers than usual at Malheur, especially Canada geese.

Two extensive irrigation projects menace this great breeding ground, one in the Blitzen River valley and the other in the Silvies River drainage area. The latter is the more threatening, as it is planned to divert all the water of that stream to irrigate lands some distance from the lake. Every effort is being made to safeguard the

water supply in order that this reservation may continue as a breeding place for migratory wild fowl. It is one of the best, if not the best, remaining in the United States, and its loss would be a real calamity.

Klamath Lake, Oreg.—The exclusion of water from this reservation has greatly decreased its importance as a wild-fowl breeding place.

Clear Lake, Calif.—This is a Reclamation Service reservoir, the impounded waters of which have not yet been used for irrigation purposes. As a result there has been an increasing growth of tules, and the reservation is now the breeding resort for an abundance of wild fowl. Large numbers of the birds formerly breeding in Klamath Lake now resort to Clear Lake. The Reclamation Service watchman has been appointed a cooperative warden and keeps the lake posted and protected. Each spring sheep have done considerable damage to the nesting resort on a peninsula in the lake, and special effort will be made to prevent this in the future. Large numbers of geese nest here, in addition to other birds.

Deer Flat, Idaho.—The boundary of this reservation lies along section lines and it is extremely difficult for the wardens to regulate trespass. The high-water mark about the lake, however, is clearly defined along the willows and sage brush. During autumn the water is low and the gradually sloping land leaves a belt of from a quarter of a mile to a mile in width between the shore line and high-water mark. In the fall of 1920 the Secretary issued regulations to permit the shooting of migratory wild fowl on the reservation outside the high-water mark. The birds thus have the benefit of an undisturbed feeding and resting place, while sportsmen may have a certain amount of shooting on the surrounding lands.

Minidoka, Idaho.—Minidoka is another irrigation reservoir. In the spring of 1921, 16 acres on an island a few miles above the dam were planted with wheat, Japanese millet, sweet clover, and blue duck millet to provide food and cover for the nesting birds. The outcome of this experiment has not yet been determined.

Nine-Pipe and Pablo, Mont.—These two reservations, created by Executive order dated June 25, 1921, cover the Reclamation reservoirs of the same names and afford breeding places for a considerable number of wild fowl. Nine-Pipe includes 2,019 and Pablo 2,854 acres. In 1920 a pair of swans (probably trumpeters) raised a brood on Nine-Pipe Reservoir and a number of swans were seen about these waters this spring. These two refuges will be under the general supervision of the warden of the Montana National Bison Range, which is only 12 miles south of Nine-Pipe and 21 miles from Pablo.

Pishkun and Willow Creek, Mont., and Shoshone, Wyo.—Each of these reservations is an irrigation reservoir and will be safeguarded by men in the Reclamation Service, who are made cooperative wardens.

Chase Lake, N. Dak.—Warden service has been maintained at this reservation during the breeding and shooting season. A peninsula in the lake is a favorite breeding place for ducks. Special efforts will be made to protect this area from live stock during the breeding season in order that the birds may not be molested.

Mille Lacs (Spirit Island), Minn., Reservation, enlarged by the addition of the small Hennepin Island, is a breeding place for gulls and similar birds. In the autumn considerable numbers of ducks congregate in the vicinity.

Big Lake, Ark., has had an exceptionally good year. Trespassing on the reservation, which was formerly so common, is rapidly diminishing. The only serious depredation in 1921 resulted in one offender being sentenced by the Federal court to pay a fine of \$500, his associate being fined \$50 and sentenced to six months in jail. Wood ducks are breeding here in greater numbers than formerly and the reservation is a resting place and sanctuary for vast numbers of other ducks in autumn and winter. Geese rarely stop here.

Walker Lake, Ark., is now under the supervision of the warden at Big Lake. A large rookery of egrets and other herons is established here, motion-picture films of which were made for educational purposes by a photographer from the department.

Reservations in the Gulf of Mexico.—These include Petit Bois, Breton, and Tern Islands and East Timbalier and Shell Keys, lying along the south shore of Alabama, Mississippi, and Louisiana, where countless thousands of sea birds and a few waders nest each spring and early summer.

The chief warden at Big Lake was detailed to patrol these gulf reservations during the spring of 1921 and among other interesting observations reported that two pairs of white pelicans were nesting on East Timbalier. This is a rare occurrence.

Key West and Tortugas, Fla..—Birds continue to nest in large numbers on Bird Key, of the Tortugas Keys Reservation, and a watchman was stationed there during the nesting season to protect it from being raided by egging parties.

MIGRATORY-BIRD TREATY AND LACEY ACTS.

Development of the administration of the migratory-bird treaty and Lacey Acts has been seriously impeded by lack of sufficient funds for their adequate enforcement. Nevertheless, substantial and gratifying progress has been made, as is evidenced by the remarkable increase in the numbers of wild ducks, wild geese, and practically all species of migratory birds. The increase among the migratory game birds is attributable almost solely to the elimination of spring shooting, the nonsale of migratory game birds, and the establishment of a uniform bag limit, the three fundamental restrictions made possible by the migratory-bird treaty act. Nearly all State game commissions and many organizations and individuals have cooperated actively with the bureau in creating an interest in the proper observance of the law, in checking violations, and in apprehending persistent violators.

The stopping of spring shooting has had a striking influence in encouraging the birds to remain within the States and to reoccupy parts of their former breeding range unfrequented by them for many years. Records are on file of birds nesting in some places on earlier dates than heretofore recorded. One noteworthy and unusual instance is the finding of four black ducks' nests—one with one, one with four, and two with six eggs—by a Federal game warden on

March 2, 1921, in New Jersey. The protection of the breeding grounds of the birds and the extension of their breeding ranges have greatly improved fall shooting and have more than compensated for the loss of spring shooting. During the last open season sportsmen enjoyed the best hunting for years, and in many sections the daily bag limit was easily obtained.

While the bureau has been unable to increase its warden force and expand the work to meet a widespread demand, the administration of the law has been systematized and perfected until now the warden force is operating in a highly efficient manner and increasingly commands the respect and confidence of the public.

The number of game wardens on duty has varied during the year from 27 to 31. These men were aided by 27 deputy wardens, who have rendered valuable services when placed on active duty at various times, and also by 326 deputy wardens located throughout the country, who receive the nominal salary of \$1 per annum and co-operate in reporting violations and in bringing about a better observance of the law. Most of the Federal deputies are also State deputy game wardens. The volume of administrative work has increased so rapidly that it became necessary during the year to add to the force a deputy chief game warden.

The small number of Federal wardens allowed has made it necessary during the spring migration to continue the policy adopted several years ago of concentrating a number of them in the most troublesome sections. Many violators were thus apprehended and a check put on serious violations over large areas. This method of patrol, while expensive, appears to be the most effective way to conduct the work in sections where violations are numerous and generally distributed.

During the year 996 violations of the migratory-bird treaty act were reported and resulted in 492 convictions, in which fines were assessed ranging from \$1 to \$500 each, aggregating more than \$9,500. In addition to fines imposed, a large majority of the violators convicted were compelled to pay costs, which in some instances equaled and in others far exceeded the amount of the fines. Federal judges dismissed 21 cases, while 56 cases were nolle prossed. Grand juries returned no bills in 17 cases, and trial juries acquitted 10 defendants. Prosecutions against 5 persons were terminated by the death of the accused; and 16 cases of a trivial or technical character were not reported by the bureau for prosecution. About 370 cases are awaiting action of the courts.

The convictions in Federal courts were distributed as follows: Alabama, 37; Alaska, 1; Arizona, 16; Arkansas, 17; California, 1; Delaware, 12; District of Columbia, 1; Florida, 24; Georgia, 36; Idaho, 7; Illinois, 44; Indiana, 1; Iowa, 43; Kansas, 8; Kentucky, 2; Louisiana, 4; Maine, 15; Maryland, 9; Massachusetts, 19; Minnesota, 3; Mississippi, 24; Missouri, 36; Montana, 7; Nebraska, 7; New Jersey, 2; New Mexico, 7; North Carolina, 5; Ohio, 7; Oklahoma, 6; Oregon, 2; Rhode Island, 2; South Dakota, 3; Tennessee, 8; Texas, 37; Virginia, 17; Washington, 21; and Wyoming, 1.

Numerous seizures were made of migratory game birds illegally killed or possessed, and most of these were disposed of by the bureau with consent of accused by gift to hospitals or charitable institutions

for use as food. Contraband plumes and mounted specimens of migratory birds of an estimated value of \$5,000 were seized during the year. Most of these were released to the bureau by the accused, while others were turned over to it by court order.

Many substantial fines were imposed, but in some cases they were very small. The Federal judge for the eastern district of Arkansas imposed the maximum penalty of \$500 on one persistent violator charged with selling wild ducks; in passing judgment on two other offenders similarly charged, the same judge fined one \$250 and the other \$50, in addition to which the latter was sentenced to six months in jail. Two of these offenders have been notorious violators of the game laws, particularly with respect to illegal traffic in wild ducks, and had previously been in Federal court on at least one occasion for violation of the Federal game laws. Each of two offenders arraigned in the western district of Missouri on charge of killing wild ducks in spring, was fined \$200 and costs. One offender convicted in New Jersey on charge of killing wild geese during the close season served 10 days in jail, but the court remitted the fine of \$200 also imposed. At Santa Fe, New Mexico, a violator was fined \$350 and costs on charge of illegally possessing two wild ducks unlawfully killed; that he was a State deputy game warden may account for the substantial fine imposed. The illegal sale of wild ducks by a restaurant proprietor to his guests resulted in his conviction and the imposition of a fine of \$100 in the Federal court at Beaumont, Tex. Many other cases netted fines ranging from \$25 to \$50 each.

The second conviction for hunting wild fowl from an airplane was obtained in the Federal court at Baltimore, Md., where the violator, charged with killing a swan, was fined \$10. The concerted efforts of three Federal game wardens on the Missouri River in the latter part of 1920 resulted in the apprehension and conviction of approximately 25 violators charged with killing ducks and geese from motor boats; in most of these cases each offender was fined \$25 and costs.

During the fiscal year 886 persons were authorized to collect and 160 to possess migratory birds for scientific purposes; 48 were authorized to capture migratory waterfowl to assist them in breeding wild fowl in domestication; and 2,139 were authorized to possess migratory waterfowl for propagating purposes. Only a small percentage of the persons to whom permits to propagate wild fowl were issued are engaged in breeding the birds for food purposes, many of the birds possessed being held merely for ornamental purposes or for use as decoys. Permits were issued to 150 responsible persons, authorizing them to trap, band, and release migratory birds in cooperation with the efforts of the bureau to obtain scientific data concerning the distribution, breeding habits, and times and lines of migratory flight of the birds.

On April 21, 1921, the Secretary issued an order permitting the destruction of nests and eggs of mergansers on the property of the Mad River Co., Oswego County, N. Y., to enable the company to protect trout and other valuable food fishes from depredations of the birds, but killing of the birds was not permitted.

Depredations of robins on cherries and other small fruits resulted in the issuance of an order by the Secretary on April 30, 1921, au-

thorizing fruit growers, under Federal permit valid when countersigned by the chief game official or his duly authorized representative in the State where effective, to kill robins when necessary to prevent the fruit from being destroyed, in New Hampshire, New York, Indiana, Wisconsin, Minnesota, and Oregon.

The order of January 17, 1919, permitting bobolinks, commonly known as reedbirds or ricebirds, to be killed in certain States from September 1 to October 30, was rendered ineffective in New Jersey, which passed a law affording these birds protection throughout the year.

The annual meeting of the Migratory-Bird Treaty Act Advisory Board, attended by practically all of its members, was held in Washington, on January 27. Most of those present were State game commissioners, and all commended the bureau for its efforts and gave it assurances of their hearty cooperation in the administration of the law.

Amendments of the Federal regulations suggested by the bureau were concurred in by the board, and these subsequently were adopted by the Secretary, approved by the President, and became effective on March 3, and May 17, 1921. The most important of the amendments provided that the daily bag limits obtained by one person shall include all birds taken by any other person who for hire accompanies or assists him in taking them; another amendment authorized limited as well as general privileges under permits issued for scientific purposes.

The effectiveness of the bureau's work has been greatly augmented by the hearty cooperation it has received from an ever-increasing number of State and local organizations of sportsmen and conservationists. In the important work of creating a healthful public sentiment to aid in the enforcement of the law, the bureau has enjoyed at all times the good will and cooperation of State game officials and of associations organized for the conservation of wild life. With this valuable aid it has succeeded in accomplishing gratifying results, not only through cooperation of such national organizations as the American Game Protective Association, the National Association of Audubon Societies, the Boone and Crockett Club, the Camp Fire Club of America, and the Camp Fire Club of Chicago, but of many of the State game protective associations.

INTERSTATE COMMERCE IN GAME.

A large number of investigations of interstate shipments of wild animals and parts thereof were made during the year, believed to have been in violation of sections 242, 243, and 244 of the Penal Code, commonly referred to as the Lacey Act. Many of these investigations have been practically completed, and 44 have been reported for prosecution. These involved mainly the shipment of beaver skins, although one shipment contained 994 muskrat skins illegally taken in Ohio and shipped to Michigan.

Eighteen convictions under the Lacey Act resulted in the imposition of fines and costs amounting to \$580, five cases were nolle prossed, and two were terminated by the death of the accused. In cases involving 120 shipments, prosecution was deemed to be unwarranted or inadvisable either because they were found to be made by

parcel post or because of the fact that sufficient evidence could not be obtained; 100 shipments are still under investigation.

Investigations by Federal game wardens frequently reveal evidence of violation of State laws in the killing or shipment of animals or birds, which can not be prosecuted in Federal court, and during the year the bureau cooperated with State game authorities in turning over to them 291 cases of this character, which resulted in the States' receiving in fines and costs a total of \$7,766.31.

Lacey Act cases reported for Federal prosecution originated in the following States: Arkansas, 2; Colorado, 2; Idaho, 8; Michigan, 1; Nebraska, 1; Nevada, 1; New Mexico, 1; Ohio, 1; Oregon, 11; Utah, 1; Washington, 7; Wisconsin, 3; Wyoming, 5.

Many important fur dealers, realizing the necessity of conserving the supply of fur-bearing animals, have continued to extend co-operation by republishing in their catalogues and in their advertising material information furnished by the bureau concerning State trapping and shipping laws and by omitting from their price lists quotations on furs of animals for which no open season is provided. The number of cases prosecuted under the Lacey Act is no indication of the widespread deterrent influence extended by the act against illegal killing and shipment of game and furs. This law is one of the most helpful conservation acts ever passed by Congress. It is of the greatest assistance to the State game officials in preventing the illicit destruction and shipment out of the States of their game and fur resources.

IMPORTATIONS OF FOREIGN BIRDS AND MAMMALS.

The number of permits issued during the year for the importation of foreign birds and mammals showed an increase of more than 20 per cent, from 453 in 1920 to about 560 in 1921, and the number of shipments inspected increased in the same time from 89 to 155. At Honolulu, Hawaii, additional permits were issued for the entry of 1,190 miscellaneous birds, chiefly quail, doves, and pigeons. Altogether there were entered in the United States under permit 66,793 canaries, 22,209 quail, and various other miscellaneous birds, making a total of 182,052, of which 129,928 were inspected. In addition, there were entered at the port of San Francisco, chiefly as passengers' baggage without requirement of a permit, 875 parrots, 1,740 canaries, 1,989 miscellaneous birds, and 128 mammals. The permits for mammals authorizing the entry of 5,368 animals included 1,574 black or silver foxes from Canada. Some of the permits for foxes were probably not used and a few others covered the entry of animals brought in for exhibition and later returned. The number actually entered was probably much less, therefore, than the figures stated, although larger than the number reported last year, 805.

On April 7, 1921, new regulations for the entry of black foxes were issued, effective June 1, which limited the ports of entry to Boston, Mass.; Calais, Me.; New York and Rouses Point, N. Y.; Pembina, N. Dak.; Port Huron, Mich.; and Seattle, Wash.; and required a number of days' quarantine at the border before entry. Since these regulations went into effect comparatively few permits have been issued, and during the month of June no foxes were en-

tered. The object of this quarantine is to prevent the entry of black foxes suffering from diseases or parasites. Large numbers of these animals have been imported for fur-farming purposes, some of them afflicted to such an extent as seriously to endanger the fur farms where delivered.

Importation of birds from Europe and Australia included several large miscellaneous consignments for zoological parks including a number of rare and interesting species. Among these was a shipment from Australia which arrived in November at New York via the Panama Canal and included 2 blue birds of paradise (*Paradisornis rudolphi*), 4 Count Raggi birds of paradise (*Paradisea raggiana*), 21 satin bower birds (*Ptilonorhyncha violacea*), 2 New Guinea mynahs (*Mino dumonti*), and many other rare species.

During the year two Hawaiian geese (*Nesochen sandvicensis*) have been received, one at New York via Hamburg and one at San Francisco direct from Honolulu. This species, confined to the Hawaiian Islands, is seldom seen in captivity and has been imported previously on only one or two occasions. Several important shipments were received from South American ports and among them those from La Guaira, Venezuela, and Para, Brazil, included a number of rare toucans, parrots, and other species which deserve mention. The traffic in Tropical American parrots, which, prior to the war, had reached considerable proportions, has shown some increase, and during the spring several large shipments of parrots from Cuba arrived at New York.

IMPORTATION OF QUAIL FROM MEXICO.

Through the cooperation of the Bureau of Animal Industry, inspection and quarantine of quail from Mexico were provided as heretofore at Brownsville, Laredo, and Eagle Pass, Tex., from November 1 until April 20. Under date of March 3, 1921, the regulations admitting quail were modified to extend the open season 10 days, until April 20. After March 10 quail examined at the border and found free from disease were permitted to enter without quarantine. The number released from quarantine was 13,564 and the number admitted on inspection after March 10 without quarantine was 8,645, making a total of 22,209 admitted. Quail disease appeared at Brownsville in December and later at Laredo. The total number of birds lost from this or other diseases and not included in the above total was 7,359. Upon the first appearance of the disease at Brownsville entries at that port were suspended for a period of about six weeks.

The number of quail imported this year was exceeded only by the totals of 1917 and 1920 when 32,814 and 27,417, respectively, were brought in. In all, during the 10 years that quail have been shipped from Mexico, 119,717 have been imported, about two-thirds of which arrived during the seasons of 1917, 1920, and 1921. The birds were sold for \$24 or more a dozen.

PROTECTION OF LAND FUR-BEARING ANIMALS IN ALASKA.

Under the appropriation act for the department for the fiscal year covered by this report, the Secretary of Agriculture was authorized to exercise jurisdiction heretofore exercised by the Secretary of Com-

merce over all land fur-bearing animals in Alaska. The work was assigned to the Biological Survey, and immediate steps were taken to carry out the provisions of section 1956 of the Revised Statutes, as amended, which provides that no otter, mink, marten, or other land fur-bearing animal shall be killed except under such regulations as the Secretary may prescribe. On July 1, 1920, regulations were accordingly promulgated in which open seasons were provided for killing land fur bearers in the Territory, with the exception of martens and beavers. On October 25, 1920, these regulations were amended extending the open season one month for trapping foxes in the southern part of the Territory.

A chief fur warden was appointed with headquarters at Juneau, and deputies were stationed at Akhiok, Atka, Fairbanks, Igloo, Killisnoo, Unalakleet, Unalaska, and Wrangell. Four employees of the Bureau of Education of the Department of the Interior on the Seward Peninsula were appointed as cooperating deputy fur wardens. In connection with the administration of this work, excellent cooperation has been extended by the Customs Division, Bureau of Education, Department of Justice agents in Alaska, the Coast Guard Service, and the Bureau of Fisheries. In addition to the fur wardens in Alaska, a warden and two deputies are stationed in the United States—at San Francisco, Seattle, and Tacoma—to investigate illegal shipments from Alaska of furs arriving at these ports. Although the funds available are inadequate to enforce the laws for the protection of the land fur bearers of Alaska, it has been possible to exercise a restraining influence in many parts of the Territory and thus to lessen greatly the illegal taking of furs.

A serious situation now exists as to the future fur supply of Alaska through the use of poison in many remote districts and through overtrapping. These conditions prevail not only because of the small appropriation available for enforcing the fur law and regulations, but because the law is inadequate to effect its purpose. It is hoped that a new law dealing with the fur bearers may be enacted in the near future.

Six seizures of contraband furs were made—one of which was later released. These included skins of 43 beavers, 13 martens, and 1 land otter. A trapper living near the Canadian boundary line on Fortymile River was convicted and fined \$100 for killing 18 martens. There are now in possession of the fur warden stationed at Fairbanks, pending final disposition by the Federal court, 714 marten and 699 beaver skins, seized at Tanana and Eagle in 1919 by a United States deputy marshal. The Bureau of Fisheries turned over to the Biological Survey the proceeds from sales of furs seized by its agents prior to July 1, 1920, but not sold until after that date, amounting to \$3,820.74.

Through cooperation of the Postmaster General, postmasters in Alaska were instructed to report to this Bureau all shipments of furs made by mail, and arrangements were also made with commercial transportation companies to report fur shipments made by express and freight. The value of the furs shipped out of Alaska, reported to the bureau for the period from November 16, 1919, to December 1, 1920, amounted to \$1,079,668.86, exclusive of pelts of blue and white foxes from the Pribilof Islands, which are under the exclusive jurisdiction of the Bureau of Fisheries.

While the total number of furs shipped during the period stated exceeds that of the previous year by 27,680, the value is \$299,678.80 less, because of a decrease in prices. The following table shows the number of the principal pelts shipped and their value:

Kinds of furs.	Number.	Value.	Kinds of furs.	Number.	Value.
Muskrat.....	138,443	\$276,896	Land otter.....	3,017	\$75,425
Mink.....	36,115	252,805	Blue fox.....	569	48,365
White fox.....	4,943	173,005	Cross fox.....	937	42,165
Red fox.....	6,469	97,035	Silver fox.....	328	41,000

FUR FARMING IN ALASKA.

The bureau has supervision of the leasing of 10 islands off the coast of southern Alaska for fox-farming purposes. Originally 12 islands were transferred from the Department of Commerce, but two of these—Little Naked (Storey) and Carlson (Grafton) Islands, being situated within the boundaries of the Chugach National Forest—were, with the approval of the Secretary, turned over to the Forest Service. The 10 islands remaining under the jurisdiction of the bureau are as follows:

Name of island.	Location.	Name of island.	Location.
Aghiuk.....	One of the Semidi Islands. Southwest of Kodiak Island.	Long.....	In Chiniok Bay, east of Kodiak Island.
Chirikof.....	One of the Semidi Islands.	Marmot.....	East of Afognak Island.
Chowiet.....	One of the Chugach Islands.	Middleton.....	Gulf of Alaska.
Elizabeth.....	One of the Shumagin Group.	Pearl.....	One of the Chugach Islands.
Little Koniugi.		Simeonof.....	One of the Shumagin Group.

All but the last named of these islands were leased during the year for fox-farming purposes—under the plan established by the Bureau of Fisheries prior to July 1, 1920—for periods of five years to the highest bidder, at about \$200 a year. Through a cooperative arrangement between the Biological Survey and the Forest Service, a uniform policy has been adopted to cover the use for fur-farming purposes of islands in the Aleutian Chain and along the southern and southeastern coast of Alaska. Under this plan the rental will be \$25 a year during the first three years of occupation, and at the expiration of this period the occupant of the island will be given the option of renewal, with a revision of the amount of rent to be paid according to the value of the location, but in no case to amount to enough to be burdensome to him. It is believed that the establishment of a uniform system of permits and rental rates covering the use of Alaskan islands for fur-farming purposes will greatly assist in developing the industry. The islands vary in area from 40 acres or less to several thousand acres. Blue foxes are the principal animals farmed on all these islands, although black-fox farming is also established on some of them. The blue foxes are practically running free on the islands, but most of the black or silver foxes are kept in pens.

In the Aleutian Chain the use of islands for fox-farming purposes is being granted to natives free of charge, owing to the lack of resources and to the difficulty they have in maintaining themselves, but the regular rental is charged for occupation by others.

More than 50 islands are occupied for fur-farming purposes in the Aleutian Chain. On some of the other islands foxes have been introduced for many years and are being trapped. During the winter trapping season of 1920 and 1921 the following fox skins of various kinds were taken in the Aleutian Chain:

Red foxes	755
Cross foxes	51
Silver foxes	43
Blue foxes	414
White foxes	10
 Total	 1,273

A new feature of the fur-farming industry in Alaska that is being observed with much interest is the propagation of martens. Four permits have been issued to residents of southeastern Alaska to capture a limited number of these important fur bearers for the purpose of stocking the forests on some of the islands.

It is estimated that at the present time about 225 Alaskans are engaged in the fur-farming industry in the Territory, with a considerable investment of capital. The industry is rapidly growing and gives indication of becoming an important one. One drawback to its development is the fact that many islands along the southern coast lie outside the national forests and the Aleutian Islands Bird Reservation and remain unoccupied because no legal authority exists by which they may be leased. It is hoped that legislation may be enacted shortly which will render these islands similarly available. This is particularly important in view of the fact that they are of little or no value for any other purpose.

THE REINDEER INDUSTRY.

From the introduction of the first reindeer in Alaska in 1892 to June 30, 1920, although these animals had increased to far in excess of 100,000, no definite expert investigation had been made concerning the grazing conditions under which the herds were living and the distribution and supply of available forage plants upon which they were dependent for both summer and winter feed. Furthermore, no investigations had been conducted to determine the diseases and parasites of the reindeer and methods for their control, and no investigations of methods of handling the herds in order to obtain the best results.

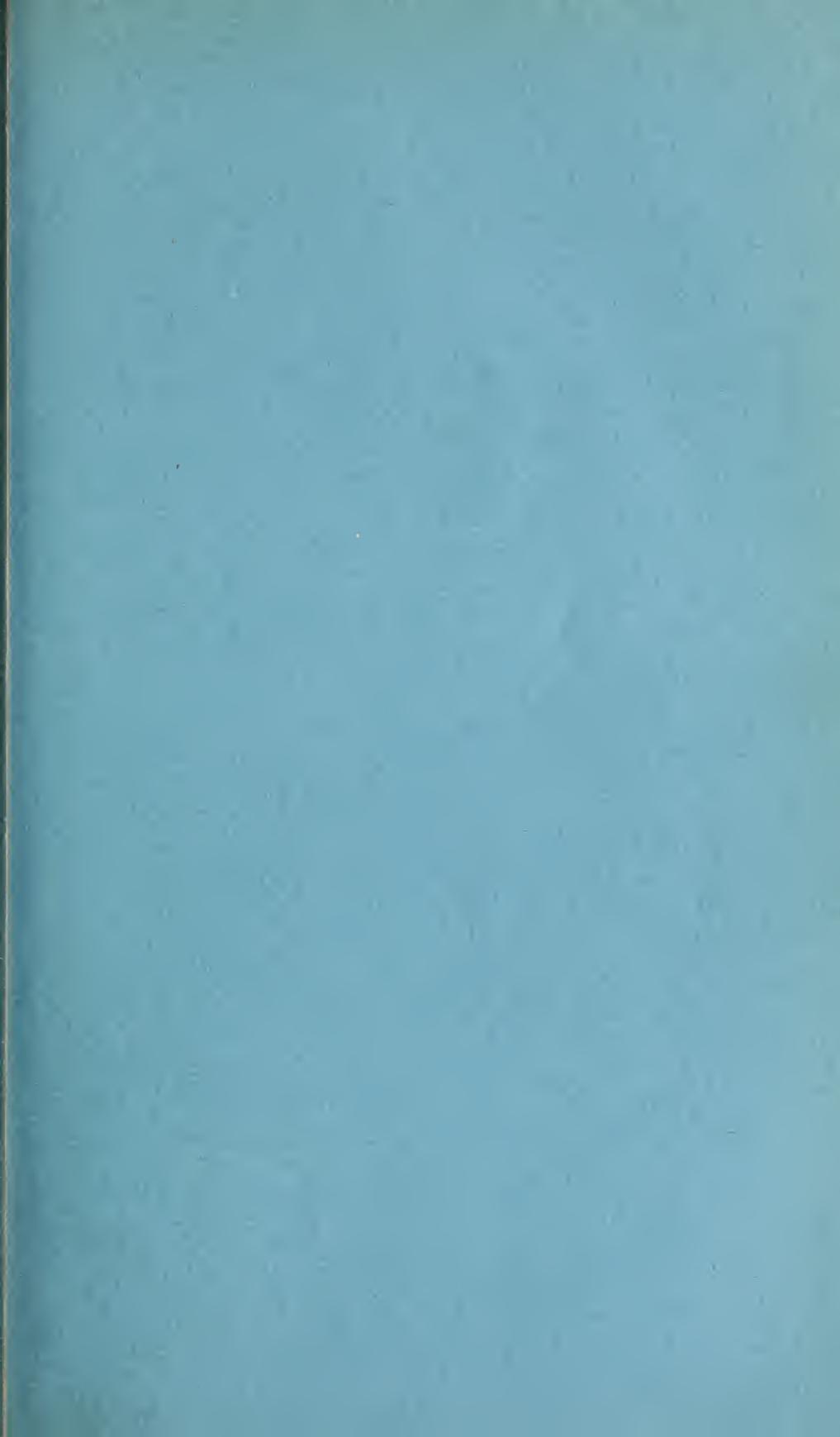
On July 1, 1920, funds became available for the Biological Survey to take up these matters. The chief of the bureau, accompanied by two grazing experts, a competent field naturalist, and a veterinarian skilled in the study of animal parasites and diseases and their control proceeded to Alaska in July and established a well-equipped reindeer investigational laboratory at Unalakleet. This has become the headquarters for the grazing and veterinary experts throughout the year. During the year the staff at this station covered several thousand miles by dog sled and boat travel. A grazing reconnaiss-

sance over thousands of square miles of territory was completed and substantial progress was made in ascertaining the parasites and diseases afflicting the reindeer, with experiments to develop methods for their control.

Great advance has also been made in devising improved methods of handling the reindeer herds. It is gratifying to know that both the natives and other herd owners showed from the outset a most wide-awake interest in the work of the experiment station, giving every possible cooperation, and before the year was over the herd owners in many instances began to put into effect recommendations given by the experts for the better handling of their herds, thus recognizing the practical value of the suggestions made. One of the most promising features of the situation has been this interest shown by the natives and their willingness to accept suggestions for improved methods of handling their herds. As a result, when the investigations are completed it is anticipated that the industry as a whole will receive a great impetus which will have a far-reaching effect.

A field naturalist stationed at Fairbanks spent the year investigating the caribou of that region, particularly the migratory herds, with a view not only to the conservation and perpetuation of this important game food supply for the interior, but also for the purpose of determining the most practicable locality and method to secure large caribou bulls to be used in grading up the size and vitality of the existing reindeer herds. These herds, through bad breeding practice, in various instances have shown signs of deterioration. This investigation has been most successful in developing the desired facts.

During the coming fiscal year it is planned to publish a bulletin giving the results of the reindeer investigations, with recommendations so far as the information obtained will warrant. This should provide the needed practical information for the development of the reindeer industry. In this connection it may be stated that the investigations into the grazing resources available for reindeer indicate that Alaska should provide forage for from 3,000,000 to 4,000,000 reindeer, the annual increase of which will furnish palatable meat for use both in Alaska and in the United States in such quantity as to form one of the greatest and most substantial of the Territorial products.



U. S. DEPARTMENT OF AGRICULTURE
EXPERIMENT STATION FILE
DEC 15 1921

REPORT OF THE CHEMIST.

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF CHEMISTRY,
Washington, D. C., July 1, 1921.

SIR: I submit herewith the report of the work of the Bureau of Chemistry for the fiscal year ended June 30, 1921.

Respectfully,

C. L. ALSBERG,
Chief of Bureau.

Hon. HENRY C. WALLACE,
Secretary of Agriculture.

When, about January 1, 1913, the Bureau of Chemistry passed to new leadership two tasks in general confronted the new chief. One was to improve the character and volume of the bureau's scientific research; the other was to make the enforcement of the food and drugs act more effective through the establishment of satisfactory cooperative relations with food and drug law enforcing officials in the States and municipalities, as well as through the development of greater uniformity in the exercise of food and drug control throughout the country.

That the scientific research work of the bureau had lagged grew out of the fact that agricultural chemistry as a distinct and independent science had lost ground the world over, and that Congress had placed upon the Bureau of Chemistry the responsibility of enforcing the food and drugs act.

When the Division of Chemistry, out of which the Bureau of Chemistry grew, was established in the days when the Department of Agriculture was still a commission, agricultural chemistry was recognized as a definite, distinct science. In the course of time the field covered by it grew so wide, so diverse, that it became split into many special subjects. The result was that the various other bureaus of the department gradually established their own chemical laboratories. For example, the Bureau of Soils deals with the whole of soil chemistry and with the chemistry of the fertilizer industry, the Bureau of Animal Industry with the chemistry of milk production and animal nutrition, the Forest Service with the chemistry of wood and of the industries that use wood as their raw materials. Even the Bureau of Plant Industry, while it has established no extensive purely chemical laboratories, employs some chemists in its various divisions.

Such was the state of affairs in 1913, and such, to a considerable degree, it still is. Much of the field of research occupied by the Bureau of Chemistry until 1900 was in this manner lost to it. The question

that had then to be faced in 1913 was into what channels should the scientific research of the Bureau of Chemistry be directed, that it might be of the greatest service to the country and to the Department of Agriculture.

Now the object of agriculture is to feed and clothe the Nation in the best way possible, and it is for the promotion of these ends that the Department of Agriculture exists. To accomplish these ends the promotion of production is not enough. The improvement of distribution and that of utilization are equally important. It is obvious that better or more economical utilization is equivalent to an increase of production. Since the improvement of the methods of utilizing agricultural products is of vital importance not merely to the farmer but to the whole country, it was decided in formulating the research policies of the Bureau of Chemistry to study the industries that utilize agricultural products, as well as to endeavor to create new or enlarge existing outlets for such products. This involved the development of a portion of the Bureau of Chemistry as a utilization service. Such a bureau, dealing with many of the industries that use agricultural products as their raw material, might be made extremely useful not merely to the agricultural interests but to the country as a whole. Since its work must articulate intimately with the production of agricultural raw materials, it can not be effective if placed elsewhere than in the Department of Agriculture.

It may perhaps be worth while to enlarge upon the value of such utilization work. The establishment of an industrial outlet for an agricultural product mainly used for food purposes may act as a stabilizer upon production and prices, since the consumption as food of such a product can not be increased largely in a year of great crop yields nor largely diminished in a year of scanty harvests. Factories, however, can operate below capacity when their raw material is scarce and high priced or work overtime when it is abundant and cheap, thus acting as a flywheel on the machinery of production and consumption. In this manner the manufacture of alcohol, starch, glucose, and dextrin has served to help in preventing gluts of potatoes in certain European countries. Had there been for corn an outlet of this general character, capable of utilizing an appreciable part of the crop, it might well have been of inestimable value to the corn-belt farmer during the past year. In the same way the development of a new outlet for a crop may mean much to the United States. Thus the area of land that can be kept under cultivation in much of the semiarid portion of the country is dependent upon the price of the grain sorghums. If it were possible to use industrially a considerable portion of the crop, for example, in the manufacture of starch, alcohol, glucose, oil, and by-product feeds, the result would be, inevitably, to bring land that can not now be farmed under the plow.

Since 1913 much work of this type has been undertaken in the Bureau of Chemistry. That more has not been accomplished is due to the Great War which kept adequate funds from being made available and caused the loss of a very large proportion of the bureau's ablest scientists. An account of some of the more notable results that have been achieved in the face of these handicaps is to be found in the following pages.

It is often a difficult problem to introduce into practical use scientific discoveries, especially when, as in the Government service,

their employment in the industries and the arts brings to the discoverer no material reward. Discoveries of great practical value not infrequently remain unused. To meet this situation, so far as the work of the scientists of the Bureau of Chemistry is concerned, an office of development work was created. As the introduction into practical use of scientific discoveries is, in the majority of cases, a matter of engineering rather than of pure science, engineers form the staff of this unit. The establishment of this office has amply justified itself and its services have been requisitioned by other bureaus of the Department of Agriculture. It is not proposed that it shall ever develop and introduce into practice inventions made outside the Government service.

Agriculture is a biological science. Even the soil teems with life. Therefore it has been the aim to develop the Bureau of Chemistry not merely as an agricultural products utilization service but also as a bureau of biochemistry. Biochemical research has been emphasized especially since 1913. To this end much of the work of the various laboratories was given a biochemical direction and in addition a protein investigation laboratory, phytochemical laboratory, microbiological laboratory, and pharmacognosy laboratory were established.

In order that the food and drugs act may be enforced effectively much original research is necessary. Few of the State or municipal officials have the opportunity, the staff, or the facilities for carrying out such researches, and they look to the Bureau of Chemistry for much of the information they require. Such regulatory investigations may in general be divided into four categories: The devising of analytical methods for the detection of sophistication; the determination of the normal range of composition of foods and drugs in order that deviations from the normal due to sophistication may be recognized; investigations to determine whether or not certain substances added to or accidentally contaminating foods are injurious to health; investigations for the improvement, control, or standardization of methods of food and drug manufacture so that manufacturers may learn to avoid inefficient and insanitary methods, very frequent causes of violation of the law. The last of these four types of investigations, since it aims to prevent and anticipate violations of the law, is essentially similar to and indeed might be classed with the utilization investigations previously discussed.

Many of these investigations demand the employment of the methods of organic chemistry, that is, of the chemistry of carbon compounds. Compounds of carbons constitute the great mass of the substances found in living things. In consequence the Bureau of Chemistry has gradually developed a large staff of organic chemists until it has come to be the chief scientific service of the Government in organic chemistry. This has resulted in the establishment of numerous contacts with that branch of the chemical industry which deals with organic substances. Such contacts were inevitable, since foods, medicines, and dyestuffs are, or consist largely of, organic substances. Since the bureau administers the food and drugs act, it has long borne as close relations to the pharmaceutical as to the food industry. With the dye industry it also long has had intimate relations, both because of its investigations upon the use of aniline dyes to color foods and because of its system of certifying to the

industry certain dyes as fit for use in food. It was therefore logical for Congress in 1916 to make an appropriation for the conduct of investigations to assist the budding American dye industry, for by that time the Bureau of Chemistry had achieved very definite recognition by chemists for its researches in organic chemistry.

Despite the many adverse conditions created by the war and discussed in the report of the chemist from year to year, the net result of the policies just outlined has been such a notable improvement in the quality and the volume of the bureau's scientific work that, during the fiscal year 1921, 140 scientific contributions were made to various technical journals. In addition, 7 department bulletins, 3 farmers' bulletins, and 3 department circulars were published and 1 department bulletin was issued jointly with another bureau. At the beginning of the fiscal year 15 applications for public service patents were pending. Eight additional applications were filed during the year; 6 were granted, 6 denied, and 11 are pending.

The responsibility for the enforcement of the food and drugs act placed upon the bureau by Congress necessarily retarded temporarily the bureau's research work because the organization of the administration of the law required, for a time at least, the services of the best minds in the bureau. It drew many of the ablest scientists into executive work and caused a sudden mushroomlike growth of the staff. Such growth always brings complications in its train. In 1913 the research functions and the regulatory functions were intimately mixed, and one was interfering with the other. Experience has shown that the same individual can not at the same time do scientific research and regulatory work and do them both well. The demands of regulatory work are immediate, those of scientific research remote. Usually research is sacrificed. Moreover, rarely is one person capable of performing both types of work equally well. Apparently one demands a different kind of mind than the other. The situation was cured, simply, effectively, and permanently, by dividing the staff into two fairly distinct services, a research and a regulatory branch. Thus only in exceptional cases has the same individual both research and regulatory duties to perform.

Such an arrangement is far preferable to the segregation of the two kinds of work in distinct bureaus. Regulatory work disconnected from research becomes wooden and unconstructive. Therefore, a purely regulatory bureau will in time develop its own research service with resulting duplications, conflicts, and vexations. Moreover, the regulatory work uncovers important problems which can be turned over to the research service for solution if both services are closely associated. Thus each service stimulates and vitalizes the other. Finally, there is the very practical consideration that men in the research service who fail to demonstrate originality may be transferred to the regulatory service where they frequently develop into excellent analysts or first-rate executives, while those in the regulatory service who show scientific originality may be recruited into the research service. Under conditions as they exist in the bureau to-day the value of both kinds of work is recognized and, while they are separated as far as practicable, the closest cooperation between the two services exists.

The segregation of the research from the regulatory work required a rearrangement of the bureau's organization. Such a reorganization was necessary not merely to separate the research from the regulatory work, but also to make the regulatory work more effective by decentralizing it so far as practicable. In 1913 the field laboratories, scattered from Hawaii to Boston and from Minneapolis to Porto Rico, reported directly to the chief of the bureau in Washington. Each inspector or group of inspectors reported directly to the chief inspector in Washington. As many inspectors were stationed in cities in which laboratories were maintained, the tendency was for them to operate independently of the chiefs of the laboratories, a source of confusion to the business world and of some friction within the service. Coordination of the work of inspection with that of the laboratories was difficult to maintain since in most localities there were two officials coordinate in authority. Moreover, neither inspectors nor chemists had been given much responsibility or much authority to take the initiative. Nearly all matters of any moment had to be passed upon in Washington. This not only deprived the field force of the stimulus that comes from the reposing of responsibility but it also overburdened the staff in Washington with such a volume of detail as to make it difficult to plan and direct the work of the force in the field. In consequence the law-enforcement work of the bureau was shaped to a not inconsiderable degree by the character of the samples collected, more or less fortuitously, by the inspectors. As a result many regulatory problems were taken up prematurely before they had been studied sufficiently to formulate a final policy or to adequately present the situation to the courts.

Such an organization of the regulatory service of the bureau as existed in 1913 was natural in the early days of the enforcement of the law when it was necessary to gather together and train a personnel in a few months. At that time few trained food or drug analysts and almost no experienced inspectors were available in the entire country. They had to be created. Obviously to inexperienced men no large measure of authority could be granted. By 1913, however, the bureau had acquired a number of experienced analysts and inspectors and many precedents had been established, either by the courts or through administrative action. It was, therefore, possible to reorganize the regulatory service so as to place a larger measure of responsibility upon the field force and at the same time to divorce the scientific from the regulatory service. This was accomplished by relegating to the field as far as possible all work that was of a regulatory character. The force in Washington then became the planning and supervising department of the bureau, its general staff, while the field force became the line or the executing department. Most of the research was concentrated in Washington, which did not preclude the establishment of special nonregulatory research laboratories in the field, such as the citrus by-products laboratory at Los Angeles, when the special character of the work demanded it.

At the same time the country was divided into three law-enforcement districts with headquarters at New York, Chicago, and San Francisco, respectively. A competent executive, responsible directly to the chief of the bureau, was placed in charge of each district and to him were made subordinate all the chemists and inspectors of the district. The districts were further subdivided into stations, each in

charge of one official responsible to the chief of the district. To the chiefs of districts a large measure of authority and initiative was granted gradually and they in turn delegated to their subordinates such authority as in the individual cases seemed to them wise. However, new matters for which no precedent or policy had been established were required to be referred to the chief or assistant chief of the bureau for decision, and the final decision as to whether or not a given case should be recommended for prosecution was reserved for the chief and assistant chief of the bureau. A system of recording the volume and character of the work of the different districts and stations was introduced and the data thus secured made accessible to the entire staff. Thus not merely was cooperation between the districts stimulated but also a healthy spirit of emulation was created between them and between the stations within a given district. This has been invaluable in promoting a sound esprit de corps and efficient work.

A system of budgeting funds that makes it almost impossible for the bureau ever to be under the necessity of asking for a deficiency appropriation was also introduced. Before the beginning of each fiscal year a definite credit is established on the bureau's books in favor of each district or other major unit of its organization. The new system of accounting makes it possible for each responsible head of such a unit to know exactly at all times the expenditures of his unit and the balance remaining to the credit of the unit. It is thus impossible for him to exceed his allotment without specific authorization from the chief of the bureau. Each unit is given the widest freedom in the matter of expenditures within the limits permitted by the fiscal regulations of the department. The wisdom of its expenditures is judged by the results it achieves.

The reorganization of the bureau in this general manner has not merely created satisfactory working conditions for the research men in Washington and made it possible for the Washington staff to take a large share in directing the field operations, but it has also increased the effectiveness of the enforcement of the law. Each year since the completion of the reorganization the number of cases sent to the courts has increased until it has become nearly double that of former years, and this with no increase in appropriations. During the fiscal year 1920-21 the increase over the preceding year was about 60 cases.

It is, of course, recognized that the number of cases sent to the courts is only a partial index of the effectiveness of the enforcement of the food and drugs act. A truer index would be the proportion of the total food and drug supply shipped in interstate commerce that is adulterated or misbranded. It is quite impossible even to estimate this. It can, however, be stated positively that only a very small proportion of the food supply subject to the law's jurisdiction is either adulterated or misbranded. The grosser forms of adulteration and misbranding commonly found before the enactment of the law are relatively scarce to-day. Present-day violations are oftenest of a more subtle character, requiring greater skill for their detection and eradication. The food and drugs act is technically and of necessity a penal statute, but in fact and in intent it is corrective legislation, and a measure of the corrective influence of the act is the true measure of accomplishment. Such corrective influence may be exercised as

much, perhaps more, by constructive educational work with food producers as by prosecutions under the act. That this is the case has long been recognized in shaping the bureau's regulatory policies. The cooperation of the food and drug industries has been sought constantly.

It has been the aim to administer the law in such a manner as not merely to protect the consumer but also to improve conditions in the industry. A vast amount of educational work has been done among producers. Many investigations have been carried on to demonstrate to them methods of better sanitation, of eliminating waste, of utilizing by-products, and of more efficient operation. Unfortunately, although the net result of this work has been large, it is of a character that can not be expressed in figures. It is, however, fair to say that to-day there is hardly a branch of the food industry that would care to return to the days of untrammeled operations which existed before the enactment of the law.

The bureau has been the country's most important training school for food and drug technologists. Many of its scientists have entered the employ of food or drug manufacturers where they have been instrumental in establishing constructive cooperation with the bureau. In many instances manufacturers have sent their technologists to the laboratories of the bureau to acquire special experience not readily obtainable elsewhere. Finally, the bureau in various ways has succeeded in making manufacturers realize that they must undertake research if their enterprises are to continue to progress. It has succeeded in making groups of manufacturers realize that it is good business for an industry to police itself effectively, thus reducing to a minimum the necessity for Government interference.

In 1913 both officials and manufacturers complained greatly of the lack of uniformity in the exercise of food control by the Federal and State Governments. Lack of uniformity increases the costs of doing business, and the increased cost is usually passed on to the consumer. It arises not merely from differences in the various laws but also from differences in the interpretation of the laws by the officials and in the application by them of different standards to the same product in different jurisdictions. To meet this situation in part, the cooperation of the Association of American Dairy, Food, and Drug Officials and of the Association of Official Agricultural Chemists was sought. A joint committee on definitions and standards has proposed for the guidance of officials definitions and standards covering a wide range of products which have been adopted almost universally. Thus one cause of lack of uniformity has been eliminated to a large extent.

Lack of uniform action on the part of officials and legislators is due not infrequently to lack of information. There was need in 1913 for some sort of clearing house for the exchange of regulatory information, not merely that in the files of the Bureau of Chemistry, but also that in the files of the various State and municipal departments and printed in journals, bulletins, and reports the world over. There was need for the elimination of a vast amount of duplications and wasted effort due to the fact that officials were not in touch with their colleagues in other localities. Therefore the office of State cooperation was established in the Bureau of Chemistry and the food commissioner of the State of Texas called to take charge. This office has

been very successful in drawing officials together, in disseminating information, in securing uniformity, and in establishing effective co-operation among the officials of the country. At the same time the bureau has welcomed such officials into its laboratories, which in many instances have served as a training school for them.

It may, therefore, be asserted in all fairness that since 1913 there has been a steady improvement in the bureau's research work, in its administration of the law, and in its general usefulness to the country as a whole. Such improvements as have been brought about have been accomplished in the face of the very adverse conditions created by the war. In times of war and reconstruction adequate funds are not available and it is almost impossible to recruit highly trained men.

FOOD AND DRUG INSPECTION STATIONS.

The chemists of the field force are stationed in 16 different cities. Most of the inspectors are stationed in the same places, with a few in other cities as well. The work of the field force is confined almost exclusively to the enforcement of the food and drugs act according to the general plans formulated by the staff in Washington. The story of what it has done since 1913, which is the story of the enforcement of the law during that period, may be found in the reports of the chemist and in the records of the courts as printed in the notices of judgment, of which 7,318 have appeared since January, 1913. During the year 1920-21, 1,677 recommendations for seizure and 608 recommendations for criminal prosecution were made through the office of the Solicitor to the Department of Justice. Table 1 gives a list of the classes of products on which action was recommended, as well as the distribution of the recommendations among the various types of products.

TABLE 1.—*Recommendations of actions on alleged violations of the food and drugs act transmitted to the Solicitor.*

Article.	Criminal actions.	Seizures.	Article.	Criminal actions.	Seizures.
Alimentary pastes.....	12	10	Ice cream.....	2	.....
Apple products.....	.....	4	Ice cream cones.....	.....	1
Apples, evaporated.....	18	.....	Jams and marmalade.....	.....	2
Beans, lima, fava, etc.....	.....	6	Nuts, walnuts, peanuts (shelled and butter).....	3	9
Beverages and beverage ingredients.....	12	69	Oils, birch, wintergreen, etc.....	7	5
Bread and cake.....	6	.....	Oils, salad, olive, table, etc.....	26	44
Candy, marshmallow crème.....	3	2	Oleomargarine.....	2	.....
Chocolate coating and liquor.....	.....	9	Olives, ripe or canned.....	1	1
Cocoa.....	13	.....	Pies, pie filling.....	8	14
Coconut.....	.....	2	Potatoes.....	5	.....
Coffee, green.....	.....	2	Prunes.....	1	3
Colors, food.....	8	71	Rice.....	.....	2
Dairy products (butter, condensed and fresh milk).....	15	7	Saccharin.....	.....	2
Drugs, crude.....	8	1	Sauerkraut.....	2	3
Drugs, various remedies.....	51	815	Shellfish.....	53	2
Drugs, stock remedies.....	7	121	Sirups, table, maple, molasses.....	6	9
Drugs, venereal disease remedies.....	5	69	Soups, concentrated and vegetable.....	.....	6
Eggs, frozen, desiccated pulp, and liquid whole.....	1	5	Spices, relishes, condiments, sage.....	6	47
Eggs, shell.....	60	5	Sweeteners.....	.....	35
Egg substitute.....	.....	10	Tomato products.....	21	79
Feeds, stock.....	134	18	Tomatoes, bulk (net weight).....	5	.....
Fish, canned.....	18	45	Turpentine.....	3	.....
Flavoring materials.....	18	11	Vegetables, bulk (net weight).....	7	4
Flour.....	1	5	Vegetables, canned.....	.....	4
Fruits, bulk (net weight).....	37	.....	Vinegar.....	5	85
Fruits, canned.....	.....	16	Water, mineral.....	18	15
Fruits, dried.....	5	.....	Total.....	608	1,677
Gelatin.....	.....	1			

Examination of Table 1 shows that prosecution was recommended most frequently upon shipments of patent medicines, including stock remedies, of stock feeds, beverages, eggs, food colors, fish and shellfish, salad oils, vinegars, artificial sweeteners, and tomato products.

The activities of the year on patent medicines were a continuation of those reported last year. Especial attention was given to preparations labeled as treatments for lost manhood, suppressed menstruation, and hog cholera. In its work on the last-named type of remedies the bureau has received the continued cooperation of the Bureau of Animal Industry.

As in the past, the cases developed against stock feeds have involved principally cottonseed products deficient in protein or otherwise failing to conform to the claims made upon the labels.

Imitation fruit beverages sold under labels implying the presence of substantial quantities of fruit juice are still being encountered, but as a result of the bureau's operations an increasing number of manufacturers have revised their labels to accord with the true composition of their products, or have actually incorporated fruit juice as an essential ingredient of the article. It has been necessary to continue the seizure of vinegar made from dried-apple products bearing labels which represent it as manufactured from the pressed juice of fresh apples. This type of substitution has exerted a seriously demoralizing effect upon the trade in genuine apple-cider vinegar.

One of the most persistent and petty types of violation which the bureau has been called upon to prevent is the short weighting of tins of vegetable oil. There is a widespread practice habitual among the smaller packers of this commodity to put out packages showing a comparatively small but constant shortage from the declared quantity of the contents. In the long run this shortage results in a substantial profit to the packer, which the consumer pays. These packers also persist in adulterating olive oil with cheaper vegetable oils and in selling the cheaper product under labels implying that it is olive oil. Repeated actions have been brought in an effort to control this type of violation.

Numerous prosecutions have been instituted against shippers of oysters and scallops who have adulterated their products with water, the cheapest and most prevalent of all adulterants.

The actions on colors have resulted from the sale of dyes represented as suitable for use in food which were either harmful in themselves or contained deleterious impurities, such as arsenic, or were mixed with large quantities of inert material having no coloring value, such as salt or sodium sulphate.

As in the past, tomato products have required much attention, owing to some manufacturers' practice of using rotten and decayed stock, or of adulterating with water or material made from tomato waste.

On July 1, 1920, the administration of the tea act was transferred from the customs division of the Treasury Department to the Bureau of Chemistry, together with the personnel of the customs division engaged in the work. This will result eventually in material economies, since the staff can be employed in the slack season of tea importations upon lines of work for which it is peculiarly qualified, such as the enforcement of those sections of the food and

drugs act which pertain to tea, coffee, and perhaps spices. A beginning has been made in the control of the misbranding of teas shipped in interstate commerce.

The service and regulatory announcements published during the year contained the text of the tea act, the new regulations for its enforcement, 36 opinions, and 2,200 notices of judgment. In co-operation with the Association of American Dairy, Food and Drug Officials, the compilation of State laws is still in progress and the compilation of administrative rules and regulations dealing with food products has been started.

Meetings have been held of the Association of Food and Drug Officials of the Southeastern States, of the Association of Food, Feed and Drug Officials of the South Central States, of the New England States Officials' Association, of the North Central Association of Food and Drug Officials, and of the Central Atlantic States Dairy, Food and Drug Officials' Association. The bureau's office of cooperation has assisted in the organization of a new group, the Association of Dairy, Food, Drug and Feed Officials, North Central States, comprising Minnesota, Wisconsin, North and South Dakota, Iowa, Nebraska, and Kansas. In this way the cooperative spirit has been fostered. During the year State officials instituted or assisted in the preparation of 263 cases under the food and drugs act, and municipal officers in 56. The distribution of these cases is shown in Tables 2 and 3.

TABLE 2.—Actions instituted by State officials alleging violations of the Federal food and drugs act.

State.	Prosecutions.			Seizures.		
	Food.	Feed.	Drug.	Food.	Feed.	Drug.
Alabama.....			5		4	1
Arizona.....			2			1
Arkansas.....			1			
Florida.....			4			4
Georgia.....			10		2	2
Idaho.....			4		1	
Illinois.....	2	1		2		
Indiana.....			18		4	2
Kansas.....			47		2	1
Kentucky.....			10		4	
Maine.....			4		8	
Maryland.....					2	
Massachusetts.....	1				1	
Michigan.....			15		4	
Minnesota.....	3		4			2
Mississippi.....						
Missouri.....				1		
Montana.....	1					
Nebraska.....					1	
Nevada.....			2		4	
New Hampshire.....					15	
New Jersey.....						1
New York.....	1					1
North Carolina.....				1		1
Ohio.....	1	3		1	6	
Oklahoma.....						8
Pennsylvania.....			3			2
Porto Rico.....					2	
South Dakota.....	1				3	
Tennessee.....			3		3	
Texas.....	2	3			2	
Utah.....					1	
Virginia.....			2			
Washington.....					1	
Wisconsin.....			1			1
Total.....	13	128	3	72	13	34

TABLE 3.—*Actions instituted by municipal officials alleging violation of the Federal food and drugs act.*

Municipality.	Prosecutions.			Seizures.		
	Food.	Feed.	Drug.	Food.	Feed.	Drug.
Akron, Ohio.....	3					
Chicago, Ill.....				3		
Cleveland, Ohio.....			1	1		1
Memphis, Tenn.....	1					
Richmond, Va.....	1			2		
Washington, D. C.....	43					
Total.....	48		1	6		1

IMPORTED FOODS AND DRUGS.

As was the case last year, the variety and quantity of foods and drugs imported into this country during the present year have increased materially. The importations during the first half of the year were especially numerous. During the latter part of the year, however, the number and variety of shipments decreased. While many samples have been examined and many shipments detained because of adulteration and misbranding, little that was new or of special interest has been noted.

An increasingly large number of shipments of gelatin have been imported. When adulteration has been detected, indicating that the products were not suitable for food or drug use, release has been given after definite proof that the product would be used only for certain technical purposes. As happens each year, new adulterants and drug substitutes have occasionally been found. The number of medicinal preparations labeled with statements of curative or therapeutic effect examined has been especially large. When these statements were of a particularly gross and exaggerated nature, the goods were refused entry. In other cases release was allowed after suitable relabeling. The number and variety of shipments of mineral water entered during the present year have been large. Some were refused entry because of unsatisfactory sanitary quality. Most of them, however, were released either in the condition in which they were received or after the removal from the label of certain statements, particularly unwarranted claims as to their therapeutic value.

Attention has been paid to improving methods of import procedure, with a view to increasing, as far as possible, promptness and efficiency.

Table 4 gives the distribution of official samples examined by the field stations during the year, but does not include samples of thousands of shipments examined in a preliminary way.

TABLE 4.—*Report of field stations for year ended June 30, 1921.*

Laboratory.	Import samples.			Interstate samples.			Investigational samples.	Miscellaneous samples.	Total samples.	Hearings.	
	Floor inspection.	Re-leased.	De-tained.	Not adulterated or misbranded.	Adulterated or misbranded.	Check.				Import.	I. S.
Central district:											
Chicago.....	1,103	229	273	183	542	56	475	237	1,995	73	189
Cincinnati.....	11	118	21	100	365	8	198	70	889	26	163
Kansas City.....	6	25	2	.....	52	.....	6	.....	55	6	157
Minneapolis.....	105	38	11	51	80	94	240	192	805	11	38
New Orleans.....	41	85	45	44	287	19	132	16	627	48	212
St. Louis.....	32	45	14	14	460	48	427	777	1,905	15	128
Total.....	1,503	528	867	512	1,786	224	1,578	1,292	6,297	379	887
Eastern district:											
Baltimore.....	217	104	20	32	256	6	820	18	1,356	11	68
Boston.....	13,443	740	338	43	168	2	214	86	1,591	193	67
Buffalo.....	521	205	324	8	154	.....	101	205	1,000	261	130
New York.....	32,755	4,108	2,085	149	420	21	1,091	92	7,937	2,079	207
Philadelphia.....	1,336	234	170	17	78	5	278	10	792	127	72
Porto Rico.....	5,215	107	330	.....	30	.....	103	205	778	329	.....
Savannah.....	.....	99	32	13	128	11	302	6	591	21	63
Total.....	53,488	5,597	3,300	262	1,334	45	2,909	628	14,075	3,021	607
Western district:											
Denver.....	92	1	4	34	171	3	164	114	491	3	47
San Francisco.....	21,130	423	652	56	158	9	661	126	2,085	654	79
Seattle.....	4,280	77	106	104	101	.....	327	459	1,174	101	65
Total.....	25,502	501	762	194	430	12	1,152	699	3,750	758	191
Grand total.....	80,296	6,636	4,429	968	3,550	281	5,639	2,619	24,122	4,158	1,685

THE WATER AND BEVERAGE LABORATORY.

When the Federal food and drugs act first came into effect the labels of mineral waters bore the names of the most serious diseases, with positive corresponding claims of cures. Five years later it was a common practice to print upon the labels the names of serious diseases, introduced by "A remedy for," "A treatment for," "Used in," or some similar statement in place of "Cures." In 1912 or 1913, it was fairly generally believed that convictions in such cases would be very difficult to obtain. Since that time the bureau has come to regard these labels as constituting serious misbranding and has been so successful in maintaining this position before the courts that the presence of even the name of a disease upon the label of a mineral water shipped in interstate commerce is at present unusual and is considered of sufficient importance to warrant immediate investigation. Furthermore, during the latter half of the period elapsing since the passage of the food and drugs act so-called lithia waters which contained only the merest traces of lithium and which were alleged to be of the greatest therapeutic value because of their lithium content have been practically eliminated from the market. A somewhat similar situation with respect to mineral waters and other drugs alleged to contain radium, which threatened to develop to large proportions following the announcement that radium effected wonderful cures, was stopped before it had achieved much momentum through publicity and prompt action under section 10 of the food and drugs act.

At the same time, the sanitary quality of bottled mineral waters shipped in interstate commerce has steadily improved. For many years it has been a practice of the water and beverage laboratory to make careful inspection of mineral water sources, with a view to eliminating contamination at the points of origin. Important mineral spas in Missouri, Texas, Arkansas, Michigan, Kentucky, Iowa, and Wisconsin have been inspected repeatedly. Attention has also been given to many individual springs in Maine, New Hampshire, Massachusetts, Ohio, Kentucky, Tennessee, and other States. The problems involved in improving sanitary conditions are complex and require not merely thorough study but the education of the proprietors and frequently of the people forming the community as well. In some instances it is necessary also to instruct the city health officer and to obtain his cooperation and that of the mayor and council, as well as that of the State food officials. Much progress has been made. The protection of the springs from contamination and the methods of handling the water have been revolutionized in some places. Chlorinating, ozonizing, and other methods of purification have been installed, individual springs have been condemned and closed, and in general the proprietors of these places have come to realize the seriousness of certain conditions and are spending large amounts of money to remedy them. The problems involved are not completely solved, but they are well on the way to solution.

During and after the World War the sanitary condition of mineral waters imported from the countries at war was carefully controlled, for it was feared that owing to the establishment of encampments and hospitals at European spas such waters might have become contaminated and might introduce disease into this country.

In cooperation with the Bureau of Fisheries, several extensive investigations of tidal waters polluted by factory effluents in such a manner as to injure the shellfish industry of the neighborhood were conducted. It was possible in some instances to bring about the remedy of this condition.

In cooperation with the Bureau of Public Roads, the very serious deterioration of cement tile in certain drainage districts of the Middle West has been studied.

With the recent great increase in soft drink consumption, much work with this industry in improving sanitation and preventing adulteration and misbranding became necessary. Inasmuch as approximately 100,000 tons of cane sugar are used annually in these products, extensive experiments were conducted during the World War with a view to introducing the use of sugar substitutes. Formulas, including such wholesome sugar substitutes as glucose, maltose sirup, refiner's sirup, and corn sugar, were evolved. Some 30,000 copies of these formulas were distributed. It is believed that this was of tremendous advantage to the bottling industry, as well as an important factor in the war-time conservation of cane sugar.

For many years samples of salt containing barium appeared on the market and promised to become a menace to health. On investigation it was found that most of these samples came from the Pomeroy district of Ohio. A thorough study of the manufacture of salt in this district was therefore undertaken, and a process devised for the removal of barium from the brines produced there. The process, patented for the free use of the public, has been put into successful

operation by one of the largest salt producers of the district. The results of this investigation had a marked effect upon the salt produced in this district, as they called attention to the need of either special care in the technical control of the works or the installation of the treatment of the brine for the removal of the barium prior to the production of salt.

About 30 publications have been issued by this laboratory since 1913. During the fiscal year papers were published under the following titles: "Some Problems in the Manufacture of Beverages," "Acids in Beverages," "Bottles and Bottle Cleaning." Several others are in press.

THE MICROCHEMICAL LABORATORY.

The microchemical laboratory, like the water and beverage laboratory, is one of the staff laboratories which can not be relieved, for the present, of a large part of that regulatory work which, when purely chemical, is done by the field force. This is due to the scarcity of microscopists experienced in the methods of examining foods. Ultimately, however, it should be possible to train enough of them to supply the field force, leaving the microchemical laboratory free to devote itself exclusively to the staff work of supervising and planning field operations and conducting those investigations that lay a basis for the law enforcement, and to carry on educational and constructive work among producers.

The work of the laboratory bears in the main upon the detection of such adulterations of foods and feeds as require the use of a microscope. This usually involves the detection of the addition of some adulterant or the recognition that the food or feed was made from filthy, putrid, or decomposed material. In many cases chemical and bacteriological analyses fail and only the microscope is capable of giving the desired information. This is especially true for such finely ground foods as cocoa, ground spices, and cattle feeds, as well as tomato and fruit products made from decomposed stock. Without the work of this laboratory the control of such products under the food and drugs act would not be possible. It also conducts the microscopical work for the Insecticide and Fungicide Board, necessary in the enforcement of the insecticide and fungicide act.

This laboratory has devised methods for the detection in food products of decomposed beans, tomatoes, and fruit, for the estimation of cocoa shells in cocoa, cottonseed hulls in cottonseed meal, rice hulls in rice bran, powdered daisy flowers in insect powder, and mowrah meal in insecticides. It has made studies of insect powder, of domestic and imported veratrum (hellebore), and of calcium oxalate crystals in the drugs of the United States Pharmacopœia, and has worked out a microscopical method for determining the relative amounts of offal in flours as a basis for flour grading. It has done original work in applying optical crystallographic methods to the microscopical examination of foods, drugs, insecticides, and fungicides, as well as much constructive and educational work among producers of certain types of foods, one result of which has been the elimination to a large extent of certain extremely objectionable practices in manufacturing and handling tomato products. Studies of

the microchemistry of alkaloids, for the purpose of their identification, have been made.

Since, with the exception of bacteriologists, pathologists, botanists, and zoologists, the staff of the microchemical laboratory represents probably the only group of experienced general microscopists in the Government service, it is called upon by other departments, particularly the Post Office and War and Navy Departments, to examine a wide range of materials. Its help is solicited especially in the determination of the kind and character of the fibers found in various textiles, including twines and ropes, in which field it has had much experience.

It has served as a training school for microscopists, especially those engaged in official work in the States, but also occasionally for those employed by manufacturers. This year six feed-control officials, including two from Canada, received such training.

THE MICROBIOLOGICAL LABORATORY.

In the utilization of agricultural products the fermentation industries play an important rôle. Fermentation and spoilage are important factors in the waste and deterioration of agricultural products. In the enforcement of the food and drugs act it is necessary to take cognizance of the spoilage of foods, since such foods, so far as they are "filthy, putrid, or decomposed," are declared by that act to be adulterated. A laboratory specializing in the study of the problems of the fermentation industries and in the study of the causes of food spoilage did not exist in this country prior to 1913, when the bacteriological laboratory of the bureau was converted into a laboratory of microbiology devoted to such studies.

OYSTERS.

In cooperation with the bacteriologists of the United States Public Health Service, this laboratory has made sanitary surveys covering practically every oyster-producing area on the North Atlantic seaboard. Special reports were prepared upon Narragansett Bay, Long Island Sound and its approaches, Jamaica Bay on Long Island, New York Harbor and the adjacent New Jersey waters, the Maurice River in New Jersey, Chesapeake Bay, and the Potomac River. The extent of sewage pollution in these areas was carefully determined and the limits within which oysters could be grown and marketed without danger to the public health were established. The industry was notified from time to time of these findings. While in a few exceptional instances the trade resisted, general compliance with these reasonable limitations has vastly improved the sanitary quality of the oyster supply.

Studies of the washing of oysters, covering a period of years, have shown the conditions under which oysters contaminated at the point of production may be purified so as to be safe for sale. It has thus been possible to specify, within easy reach of oyster-consuming centers, clean waters in which proper exposure for periods varying from 24 hours to a week would bring most lots of shellfish to proper condition. However, a recent adaptation by the United States Public Health Service, cooperating with the Bureau of Chemistry, of the use

of hypochlorite as a purifier may in time displace the transplantation method of purification.

The freedom of oysters from evidences of pollution during the cold weather has been fairly well established by studies of their hibernation. The temperature limits for the waters which bring oysters in polluted areas to a condition in which they are no longer dangerous have been determined. Establishment of this condition for particular areas season by season made permissible the marketing of oysters from many areas that otherwise would have been closed.

MILK, EGGS, AND BUTTER.

In cooperation with the Bureau of Animal Industry and with the field force of the Bureau of Chemistry, systematic campaigns were conducted to eliminate from interstate commerce shipments of milk and cream either highly contaminated with bacteria or in which incubation had produced enormous numbers of organisms. These campaigns involved not a little scientific research and much education of producers, shippers, and distributors in proper methods of handling this important perishable. The result has been an appreciable improvement in the quality of the milk supply in a number of cities, notably in New England and the Mississippi and Missouri valleys.

In order to keep from interstate commerce decomposed frozen eggs unfit for food, chemical and bacteriological studies upon the decomposition of eggs were made. Data which make it possible to determine whether a given lot of frozen eggs is fit for food were obtained. This information has been applied in the enforcement of the food and drugs act.

A similar investigation of the materials used in the manufacture of butter is still in progress, the microbiological laboratory and the office of food control cooperating. A method has been devised to make it possible to determine from the analysis of a market sample of butter whether or not it has been manufactured with a neutralizer.

SARDINES.

With the growth of the canned sardine industry of Maine carelessness in dealing with the fish developed, as a consequence of which some decomposed fish were included in the pack. Bacteriologists and chemists of the bureau cooperated in studying conditions, and in 1921 Department Bulletin 908, "The Maine Sardine Industry," was published. Recommendations were made to the packers, which many accepted gladly. The minority were forced to change their methods through the application of the provisions of the food and drugs act. The net result was a cooperative organization of the packers for the purpose of policing themselves. Thus the bureau succeeded in establishing a most important precedent, which has since been followed in other industries. Obviously the ideal condition is for an industry to police itself so effectively that Government interference is unnecessary.

COMMERCIAL BOTTLED WATERS.

In connection with the work of the water and beverage laboratory, the bacteriologists of the bureau made an elaborate study of the

microorganisms found in commercial bottled waters and of the longevity of these organisms under the conditions prevailing in the commercial handling of such bottled products. It was shown that a clean water might be seriously contaminated by the methods of handling in the bottling establishment, so that the product appearing in interstate commerce was distinctly bad, and also that many supplies which were used in the production of bottled waters were contaminated at the source. Furthermore, it was shown that natural or artificial carbonation materially affects the flora of particular waters. It was found that carbonic acid, as used in the carbonation processes, was very effective in the highly purified types of water in destroying the organisms associated with pollution, but less efficient in the case of water in which high salt contents of certain types occurred.

FERMENTATION STUDIES.

The peculiar bacterial flora of salted products has been studied. The microbiological laboratory has made a number of fermentation studies. Thus it has shown that the many failures of sauerkraut manufacturers result from an attempt to ferment cabbage at a temperature too low to permit of the normal development of the lactic-acid-producing flora. Methods devised to control the temperature at which the shredded cabbage goes into the sauerkraut vat have proved a practical solution of this difficulty under factory conditions. In pickle fermentation a difficulty arises from the cucumber's deficiency in sugar. The lactic-acid-producing flora therefore does not automatically dominate the fermentation unless especially favorable conditions are created for it. The cucumber is naturally so contaminated with soil as to produce an extensive infection of the pickle vat. It was found by experiment that brine strong enough to control the organisms which soften and destroy the cucumber must contain at least 8 per cent of sodium chloride. In this fermentation, the necessity of strict control to obtain a normal product free from spoilage has been clearly established.

In cooperation with the States Relations Service, the possibility of utilizing some kinds of excess fruits or vegetables in small lots for the production of vinegar for local use has been demonstrated and information concerning the methods used disseminated widely throughout the Southern States.

The possibility of using excess potatoes for cattle food in the form of silage was developed in Germany some years ago. The German practice consisted primarily in grinding the potatoes and placing them in trenches in the ground. Large losses were the rule rather than the exception. In carefully controlled experiments it was shown that the introduction of freshly ground corn meal to an amount equaling or exceeding $1\frac{1}{2}$ per cent of the potatoes used would insure a prompt and efficient souring of the entire mass. In this way the losses, which often reach 50 per cent in the German practice, could be cut to practically nothing.

Increasing quantities of oriental food products produced by specific types of fermentation are being imported. Perhaps the most important of these is soy sauce. While these products are not of great commercial importance, they enter into so many special food

products in the form of sauces that a sound knowledge of the conditions surrounding their production is eminently desirable. Moreover, information which would make it possible to produce them in this country should be made available. Soy fermentation has been studied and the methods of producing soy sauce mastered. Studies upon the Japanese product "miso" and upon Chinese red rice, or "ang khak," produced with the aid of *Monascus purpureus*, are in progress.

FOOD POISONING.

The recognition of botulism in the United States, due to the work of Dickson in California about 1914, furnished the basis for instituting in the bureau a study of food poisoning. The work thus far has been limited largely to the study of the type of poisoning represented by the activity of the *Bacillus botulinus*. Two years of fundamental work were done in the laboratory, with the cooperation of the Bureau of Animal Industry, before it became generally recognized that foods coming within the jurisdiction of the food and drugs act might produce botulism. Studies in this laboratory have shown that the presence of this organism has caused poisoning from eating canned asparagus, canned olives, and canned spinach. Every effort has been made to establish as fully as possible the character of precautions necessary to protect the consuming public from the danger of this type of poisoning, and the information has been disseminated widely.

The importance of food poisoning which shows itself in violent enteric symptoms without the great mortality found in botulism has led to an investigation of the enteritidis group of organisms. In this case the laboratory is still laying foundations as it did in its study of *Bacillus botulinus*.

MOLD FLORA.

The laboratory has been carrying on a continuous study of saprophytic molds responsible for spoilage and fermentation. So far as possible, a careful survey of the mold flora of every food product coming into the bureau for inspection is made. Thus, in time, full information concerning the normal flora of many kinds of food will be accumulated. In the course of this work a large collection of organisms has been gathered and from this collection authentic material is furnished to investigators the world over.

PUBLICATIONS.

Papers covering a series of organisms important in fermentation and spoilage problems have been issued. These include the group centering upon the species *Aspergillus niger*, which has formed the basis of the commercial production of citric acid and includes strains occurring constantly in all sorts of foodstuffs, one centering on *Aspergillus fumigatus*, which appears as a pathogenic organism in the aspergillosis of birds and occasionally of man, and *Aspergillus flavus*, *A. oryzae*, and associated species. Other contributions made during the year appeared under the following titles: "A Bacteriological Study of Canned Ripe Olives," "The Flora of Corn Meal," "The Possible Pathogenicity of *Bacillus Botulinus*," "The Decomposition of Feedy Salmon," "Bacterial Decomposition of Salmon,"

"Bacterial Groups in Decomposing Salmon," "The Identity of *Aspergillus Oryzae*," "The Relation of Mosaic Disease to the Pickling of Cucumbers." The following papers are in press: "Mold Hyphae in Sugar and Soil Compared to Root Hairs," "Trehalose Fermentation in the Differentiation of the Paratyphoid-enteritidis," "The Story of Sauerkraut and Its Production."

THE CATTLE FOOD AND GRAIN INVESTIGATION LABORATORY.

The work of the cattle food and grain investigation laboratory deals in the main with the control of the adulteration and misbranding of feeding stuffs, its investigations furnishing the basis for the work of the field force upon feeds. It has cooperated with the Association of Feed Control Officials of the United States in the establishment of definitions for the feeding stuffs in common use, and has studied the milling of rice and the crushing of cotton seed, copra, and peanuts. With a view to their utilization as feed, certain waste products, such as olive pomace, almond hulls, fruit and vegetable cannery waste, mesquite beans, and various waste seeds, have been investigated.

This laboratory has made physical and chemical studies of the kafir kernel as a first step in the development of wider uses for the grain sorghums. In cooperation with the Bureau of Plant Industry, it has determined the composition of many of the native pasture grasses of the United States. It has responded to many calls to conduct analyses for various branches of the Government, and has done extensive work on the standardization of analytical methods, especially for moisture and fiber determinations.

THE PHARMACOGNOSY LABORATORY.

The pharmacognosy laboratory was established in 1914 for the purpose of supervising the control over crude drugs exercised by the field force under the food and drugs act and for the conduct of such pharmacognosy investigations as are required for the efficient enforcement of the law or are designed to prevent waste or improve the utilization of crude drug products.

This laboratory considers appeals from the decisions of the field force in the case of crude drug importations and makes appropriate recommendations to the administrative officers. In this connection it has encouraged the introduction of new crude drugs or of new sources for well-known drugs whenever this seemed useful. It has made a survey of the crude-drug gathering industry of the southern Appalachian region, and has contributed much to the standardization of crude drugs for purity, especially with reference to acid-insoluble ash as an index of cleanliness. It has studied volume-weight determinations as a means for the rapid detection of inferiority, and is taking an active part in the work of revision of the United States Pharmacopeia and National Formulary. To facilitate the identification of crude drugs a large collection of authentic samples, comprising a great number of plant products from all parts of the world, has been accumulated. The catalogue of this collection has been distributed to the field laboratories of the bureau and to the curators of other similar collections. Many new forms of sophistication have been discovered and described.

The pharmacognosy investigations include studies upon cyanogenesis and the determination of hydrocyanic acid, upon the occurrence of oxalic acid in crude drugs, upon saponins from various sources, upon *Simaba cedron*, *Piper bredemeyeri*, Veratrum, Viburnums, Hydrastis, Ipecacuanha, Salvias, *Zamia*, *Solanum macrocarpum*, *Calocarpum*, *mammosum*, *Brassica*, and beans of the Lima type. The studies upon Brassicas have made possible their classification into products suitable and unsuitable for mustard, so that the range of seeds adapted to condimental purposes has been extended. A simplification of the method for the determination of their volatile oils has been introduced. Methods for the differentiation of tropical beans of the Lima type from ordinary navy beans have been described and the range of the amount of hydrocyanic acid occurring in Lima type beans determined. Tropical beans of this type offered for importation during the war-time bean shortage contained harmful amounts of hydrocyanic acid and were excluded from the country.

Work has been done on the improvement of methods of cleaning crude drugs by washing, flotation, sifting, blowing, scraping, and other means based on differences of density, size, shape, or consistency.

In connection with the boll-weevil investigations of the Bureau of Entomology the cotton plant was studied. The distribution over the plant of the oil glands was determined and a volatile oil decidedly attractive to boll weevils separated.

An investigation of the value of microsublimation in food and drug analysis is in progress.

THE DRUG DIVISION.

The drug division conducts research work required in the enforcement of the food and drugs act, in so far as it applies to drug products other than crude drugs. This consists mainly of analytical methods for the quantitative estimation of substances used as medicines but also includes studies upon the methods of manufacturing medicinal products. For example, extensive investigations have been made upon the methods of manufacturing the various types of tablets. Among the materials for which analytical methods have been developed may be mentioned Peru balsam, aromatic spirits of ammonia, spirits of nitrous ether, santonine, paregoric, papain, pepsin, antipyrine, acetylsalicylic acid, phenacetin, salol, pyramidon, theobromine, hexamethylene tetramine, monobromated camphor, and guaiacol. This division has also done much work upon essential oils, such as chenopodium, sassafras, wild mustard, anise, fennel, clove, and pimento oils.

It cooperates in the revision of the United States Pharmacopœia and assists the Post Office Department in closing the mails to persons or firms doing a fraudulent business in the sale of medicines and related products, and of therapeutic and similar treatments sent by mail, thus reaching many frauds which can not be touched by the food and drugs act.

THE PHARMACOLOGICAL LABORATORY.

In connection with the enforcement of the food and drugs act, the pharmacological laboratory conducts investigations to determine

whether substances that have been added to or that contaminate foods may be deleterious to health and considers also the potency of drugs. Among the substances studied are caffeine and some of its isomers, saponins, tartrates, citrates, malates, succinates, oil-soluble dyes, some of the heavy metals, especially tin and zinc, iodine, and iodides.

This laboratory has also carried on a series of pharmacological or toxicological studies, in part independently, in part in cooperation with other bureaus, upon a variety of subjects important in the prosecution of various lines of work of the Department of Agriculture. For example, in cooperation with the Bureau of Biological Survey, studies have been made with a view to developing more efficient rat poisons. The toxicity of cotton seed and cottonseed meal has been investigated. From this laboratory came the warning to physicians treating the hookworm disease that the vermifuge *chenopodium* oil is so toxic as to require great care in its therapeutic administration. The chemical composition of this oil was thoroughly investigated and steps taken which it is hoped will lead to the substitution of ascaridol, the active principle of the oil, for the oil itself. This should make more exact dosage possible and lessen the chance for fatalities.

During the fiscal year 1920-21 there were published Department Bulletin 915, "Toxicity of Barium Carbonate to Rats," as well as the following papers: "A Comparison of the Effect of Certain Saponins on the Surface Tension of Water with Their Hemolytic Power," "Some Observations upon the Behavior of a Fixed Oil (Peanut Oil) Injected Intraperitoneally."

Work on the effect of strychnine upon rats has been completed. The work on arsenic has been extended, with results of importance in connection with the use of this poison as a vermin exterminator, and in connection with its occurrence in food. Some of the results seem to throw doubt on much of the reported work on "habituation" to arsenic.

The investigation of poisoning by cotton seed has made progress. The occurrence of gossypol, the toxic principle, in different samples of cotton seed was studied. It was found that a seasonal variation could occur in the same variety of cotton, that seed tending to run high in oil and low in protein usually runs high in gossypol, and vice versa. That variety rather than locality of production influences appreciably the gossypol content of cotton seed could not be proved. The variation of the gossypol content found in different specimens of seed was about 300 per cent. By animal feeding experiments it was demonstrated that the toxicity of a given sample of seed is approximately proportionate to its gossypol content. The symptoms produced do not differ from those resulting from the administration of comparable doses of pure gossypol. In chronic intoxications the nervous system (paralyses), the circulation (œdema of the lungs), and the metabolism (negative nitrogen balance) are affected. In acute intoxications gossypol is a cardiac poison, producing œdema of the lungs with congestion and, in suitable dosage, a red running of the nose.

During the year studies upon intoxication with zinc and upon the chronic intoxication with small amounts of cadmium were completed. Studies upon the toxicity of aliphatic alcohols, and alkyl

esters were begun. These are needed in determining the bureau's policies with reference to the use of certain synthetic flavoring substances.

THE CARBOHYDRATE LABORATORY.

The work of the carbohydrate laboratory since 1913 may be divided into four categories: The determination of the physical and chemical properties of the sugars and their derivatives; the improvements of the methods of preparing the rare sugars; the study of methods for the analysis of sugar-containing products; and work on improving methods of manufacturing sirups, sugar, and carbohydrate-containing products.

SUGARS.

The work on the constitution, the mutarotation, and the rotatory power of sugar and sugar derivatives, and on the action of enzymes upon sugars has won international recognition for the laboratory. Two new sugars, containing seven carbon atoms in the molecule, the first of their type occurring in nature, were discovered. Many of the methods originated by the laboratory for the preparation of rare sugars are now in commercial use. Certain rare sugars that were formerly chemical curiosities have been made available to investigators. Rare sugars not procurable in commerce are distributed to bacteriologists and others. Methods have been devised for the estimation of cane sugar by means of an enzyme from yeast, for the analysis of maple sugar and sirup, of sorghum sirup, of honey, and for the estimation of raffinose.

SUGAR AND SIRUP MANUFACTURE.

The work carried on for some years prior to 1917 to produce more powerful decolorizing carbons for use in sirup and sugar manufacture proved the starting point for the production of carbons used in American gas masks during the war. Since the war the laboratory has continued work on the use of such carbons in sirup and sugar production. Improvements have been introduced in the manufacture of maple products, of cane and sorghum sirup, and of jams, jellies, and preserves, while some of the problems of the confectionery industry have been studied.

In continuation of the work on methods for preparing better quality sugar-cane sirup, the following publications were issued and sent out to the sirup producers in advance of the cane-grinding season of 1920: Department Bulletin 921, "Sugar-Cane Juice Clarification for Sirup Manufacture;" Department Circular 149, "Cooperative Cane-Sirup Canning;" and "Manufacture of Sugar-Cane Sirup so as to Prevent Crystallization and Fermentation."

In order to demonstrate the invertase method for making sirup of improved keeping quality, a considerable amount of invertase, prepared from yeast in the laboratory, was furnished to cane-sirup producers who expressed an interest in the process, and a chemist was sent south to assist the sirup producers in the use of this method. Cooperative work with several cane-sirup manufacturers was conducted for the purpose of comparing various methods of clarification.

Cooperative work was conducted with several cane-sugar producers for the general purpose of investigating existing factory problems, the ultimate object being to improve present practices. A paper on "The Use of Kieselguhr for the Clarification of Cane Juice," comparing the physical and chemical properties of various grades of this material and their corresponding clarifying efficiency, has been prepared for publication. Experimental work was conducted in Louisiana to compare the existing sulphur-lime method of clarification with a more recently proposed process, in which kieselguhr and decolorizing carbon are employed. The results of part of this work are given in a paper entitled "An Investigation of the Composition of the Sirup Precipitate Obtained in the Manufacture of Cane Sugar by the Use of Kieselguhr and Decolorizing Carbons."

Studies in beet-sugar technology from a chemical standpoint are being carried out in the field in cooperation with beet-sugar factories. This investigation has for its object the critical study of various impurities derived from the beets and the determination of the rôle played by these impurities in certain factory troubles. The work so far undertaken includes a study of raffinose and methods for its determination, the character and amount of colloidal material (including gums) present in diffusion juice obtained from beets under various conditions, the character and amount of colloidal material present in various beet-sugar house liquors and products, and the part played by such colloidal material in sugar-house processes. The following papers have been prepared for publication: "A Study of Beet Gum: I. Preparation from Final Molasses" and "Colloids in Beet-Sugar House Liquors and Products."

The method for the production of an edible sirup from sweet potatoes discovered by the bureau in 1919 has been perfected and the commercial development of the process undertaken on a semimanufacturing scale in Georgia. Cost data and operating details are being learned. The outlook for the establishment of a small sweet-potato sirup industry is promising.

STARCH.

Studies have been made on the manufacture of starch from such sources as the white potato, the sweet potato, and the grain sorghums.

UTILIZATION OF CORNCOBS.

The work upon the utilization of corncobs, which has been in progress for some years, has passed into the semicommercial development stage. Methods of increasing the yields of furfural have been devised, so that it should be possible to produce relatively cheaply this aldehyde, useful as a solvent for resins and varnishes, as a paint remover, and in the production of condensation products of the bakelite and condensite type.

PUBLICATIONS.

In addition to the publications previously mentioned, the following were completed during the year: "Crystalline Chlorotetracetyl Fructose and Related Derivatives," "Sedoheptose, a New Sugar from *Sedum Spectabile*," "Volemite," "Cellulose Phthalate: Its Preparation and Properties," "Improvement in Sirup Manufacture,"

"The Preparation of Rhamnose," "Optical Properties of a Series of Heptitols," "Occurrence of Diastase in the Sweet Potato in Relation to the Preparation of Sweet Potato Sirup," "A Practical Study of Corncob Utilization," "A Precipitate Obtained from Cane Juice After Clarification with Kieselguhr and Decolorizing Carbon," "The Effect of Some Decolorizing Carbons upon the Color and Colloids of Cane Juice," "The Effect of Varying Hydrogen Ion Concentration upon the Decolorization of Cane Juice with Carbon," "The Preparation of Sweet Potato Sirup."

THE OIL, FAT, AND WAX LABORATORY.

Before 1918 the oil, fat, and wax laboratory conducted investigations upon the improvement of the methods used by oil analysts upon the composition of oils, fats, and waxes, and upon technological problems important to the oil and fat producing industry. It also cooperated with the Bureau of Plant Industry and the Bureau of Markets in determining the variations in quality and quantity of the oil obtainable from a number of oil seed crops dependent upon the variety of the plant grown and the locality. Such studies were made especially in the case of the soy bean and the peanut. In part through the efforts of this laboratory, cooperating with other bureaus of the department, a small-scale virgin peanut oil industry became established. An efficient battery of extraction apparatus for the determination of oil by extraction with volatile solvents was designed and introduced. In cooperation with the Food Administration, Department Bulletin 769, "The Production and Conservation of Fats and Oils in the United States," the first survey of the whole oil and fat industry, was issued.

Since little of importance concerning the actual composition of oils, even those like cottonseed which has been of great commercial importance for many years, was recorded, it was determined in 1918 to undertake the systematic research necessary to supply this information of fundamental importance to the oil-producing and oil-consuming industries, especially to hydrogenators of oils and to soap makers. Among those studied are cottonseed, peanut, tomato seed, okra seed, Hubbard squash seed, and cantaloupe seed oils. In the course of this work a small amount of myristic acid was detected in cottonseed oil, and the presence in this oil of both stearic and arachidic acid definitely proved. Moreover, an extensive investigation of the influence of the locality of production of the seed upon the composition of the oil obtained from it was made. Contrary to the indications from previously published analyses, the results showed that the chemical and physical characteristics of the oils from seed grown in different localities of the cotton belt are remarkably uniform. A study of the composition of Spanish and Virginia peanut oils has been nearly completed.

During the year 1920-21 the following papers were submitted for publication: "Okra Seed Oil," "The Composition of Hubbard Squash Seed Oil," "The Composition of Cottonseed Oil," "Cantaloupe Seed Oil," "The Influence of Geographic Source of Seed on Cottonseed Oil," "Note on the Titer of Authentic Samples of Cottonseed Oil," "The Analysis of Otoba Butter," "Menthol and Phenyl-

hydrazine Derivatives of the Higher Fatty Acids," "Methods for the Examination of Cacao Butter."

THE CITRUS BY-PRODUCTS LABORATORY.

The citrus by-products laboratory was established at Los Angeles, Calif., in 1914, for the purpose of devising methods for the utilization of cull oranges and lemons. It has been an important factor in the establishment of the manufacture of citric acid, lemon oil, orange oil, marmalade, and candied peel in California and has done work looking to the same end in Florida. A method has been evolved for the manufacture of a high-grade orange vinegar, and studies looking to the improvement and standardization of the methods of sweating lemons are in progress. Two important problems, however, still remain to be solved. One is the invention of a method for the production of lemon oil of the same composition as the hand-pressed oil of Sicily, as the oil now being produced is often deficient in certain valuable ingredients. The other is the discovery of a satisfactory method for the preservation of orange juice.

The laboratory made an important study of the chemical changes that take place in oranges and grapefruit during ripening as the result of which definite standards of maturity were proposed so as to make it possible through procedure under the food and drugs act to keep unpalatable immature fruit from the market. This has been of great benefit to honest producers, and the bureau's standards of maturity for oranges and grapefruit have been enacted into law in California and Florida.

The laboratory has become the consulting chemical branch of the Department of Agriculture for much of the research that is going on in California. In cooperation with the Bureau of Plant Industry, it has determined the variations in composition of oranges, lemons, and grapefruit, dependent upon variety, soil, and location. For purposes of propagation, in connection with that bureau's investigations on bud variation, it has studied the composition of the fruit of individual selected trees. The purpose of all this work is to improve and standardize by rational selection the varieties grown. In cooperation with the same bureau and for similar purposes, it has studied the composition of avocados. In cooperation with the Bureau of Markets, it has studied, both in California and Colorado, the chemical changes that take place in the ripening of cantaloupes for the purpose of improving the criteria used in determining when they are in the best condition for shipping.

THE FOOD RESEARCH LABORATORY.

The food research laboratory, organized originally to develop criteria for judging food products subject to the food and drugs act held in cold storage, soon grew into an important constructive service to the poultry and egg-handling industry of the country. It determined what chemical changes take place in poultry and eggs when held in cold storage for short and long periods. It developed and introduced into general use more efficient and sanitary methods of killing, bleeding, picking, chilling, freezing, and packing poultry. It studied the causes of the deterioration of shell eggs and proposed

remedies which have been widely adopted. It introduced improved methods of candling, chilling, handling, and transporting eggs. It studied the breakage of eggs in transit and the suggestions it has made with reference to the flats and fillers for egg cases, to the construction of eggs cases and their stowing and bracing in freight cars, and to the switching of freight cars in the yards have contributed materially to the reduction of a great economic loss. It has revolutionized the egg-breaking industry of the country. It introduced improved and more sanitary methods in the egg-drying industry before this business was transferred by American firms to China. It studied refrigeration in transit, the efficiency of refrigerator cars, and methods of icing them. Its recommendations have been adopted widely by the railroads and many of its suggestions are embodied in present-day refrigerator rolling stock design. This laboratory was peculiarly successful in translating its discoveries into everyday practice.

In 1914, following an understanding with the Bureau of Fisheries, the food research laboratory undertook work upon the handling, transportation, and utilization of sea foods analogous to that it was doing upon poultry and eggs. It determined the food value of fish, the chemical composition of which was unknown. It studied the changes in food value of fish dependent upon size, condition, and season, methods of icing, freezing, and transporting fresh fish and of preserving them, such as salting, smoking, kippering, and canning, the changes frozen fish undergo in cold storage for long and short periods, and the utilization of fishery by-products. It succeeded, especially during the war, in widening the consumption and in organizing the more rational distribution over the railroads of fish, particularly from the Gulf of Mexico. As in the case of the handling of poultry and eggs, so the work of this laboratory represents almost the first fundamental scientific work upon the American fish-handling industry.

No money has been appropriated for the continuation by the bureau after July 1, 1921, of either the poultry and egg work or the fish work. Therefore at the close of the fiscal year the work was stopped, the food research laboratory closed, and its staff disbanded.

THE LABORATORY OF DEHYDRATION.

In connection with the development of the bureau's utilization program, outlined in the introduction to this report, attention was given to the preservation of fruits and vegetables by drying, in the belief that this method is destined some day to play an important rôle in the country's food-preserving industry. At first the work was carried on in the fruit and vegetable utilization laboratory, where investigations were made upon the relation of moisture content to keeping qualities of raw dried vegetables, upon the effect of heat on different dehydrated vegetables, upon the preparation and keeping qualities of dried soups, and upon the keeping qualities of steam-blanching potatoes.

During the war the subsistence division of the Quartermaster Corps looked upon the fruit and vegetable utilization laboratory as the real source of information on dehydration. The corps inspectors were sent to the bureau for instruction before going out to dif-

ferent plants to supervise the manufacture of materials for the Army. Contractors for the Army received advice and instruction, especially in the drying of potatoes. The standards for the dried vegetables contracted for by the United States Army were the result of information furnished the Quartermaster Corps. The bureau insisted on a moisture content of 10 per cent or less for all products at that time and also advised blanching if the moisture content was much above 7 or 8 per cent. In the case of potatoes, which must be either blanched or sulphured to preserve the color, the bureau took a firm stand against sulphuring. Largely as a result of this stand, no dehydration plants are attempting to sulphur vegetables at the present time. The bureau was able to recommend heat limits in drying for some products, such as potatoes, and to give advice on steam blanching. It is noteworthy that the potatoes produced for the American Army were greatly superior in quality to any of those produced by the Canadian plants. At the time of the signing of the armistice the drying plants of the United States were putting out dried potatoes of excellent quality, which have not yet been surpassed.

During the war Congress made a specific appropriation for the conduct of work to promote the industry of dehydrating fruits and vegetables, making possible the establishment of a special laboratory of dehydration. Since the armistice was signed both laboratory and field investigations have been conducted with a view to improving the quality of the commercial products. The industry requires much research work before uniformly good products will be found universally upon the market. Each fruit or vegetable presents specific problems which must be studied to find the answers to such questions as which is the best variety for dehydration purposes, at what temperature and with air of what humidity should it be dried, what preparatory treatment, such as blanching, should it be given, to what degree should its moisture content be reduced, and how should it be packed, handled, and stored. A series of years will be necessary to complete the investigations of this character now in progress.

Studies on the best design of plants and on the costs of operation are also necessary. Such studies on fruit artificially dried in California as compared with the sun-dried, sulphured fruit, have been made and published. It is hoped that the results, which were not unfavorable to artificial drying, will help to hasten, in the case of some fruits at least, the substitution of artificial drying for sun drying which is subject to the hazards of the weather and which, in many cases, produces a less desirable product. In Oregon and Washington, where the climate is unfavorable to sun drying, this matter is vital to the fruit industry, and there the bureau is doing cooperative work with the local agencies. In cooperation with the Bureau of Plant Industry, the Bureau of Chemistry has also been of assistance in establishing the drying of raisin grapes in California. Furthermore, methods have been devised for the improvement of the process for making potato flour.

Men trained in the principles of food chemistry and engineering have visited most of the commercial plants, where they have often been able to be of assistance. For example, an engineer connected with the work studied conditions in one plant, securing such information that the management was encouraged to make alterations

enabling it to add 50 per cent drying capacity to the tunnels without any additional radiation. According to a census taken in cooperation with the University of California, 148 drying plants, employing many types of equipment, were operating in California during the past season. Studies on these driers have been made with a view to determining which is the most efficient for each crop. The majority of these drying plants are of small capacity, and the owners or managers are not always adept in their operation, nor can they afford to employ expert help. The bureau's representatives have been able to assist them in many ways.

As important as improving process and products in establishing the dehydration industry on a firm basis is the creation of a market. Though many of the dehydrated products are excellent, the public is slow to use them because ignorant of what may be expected of them. Therefore, a special campaign has been conducted by the bureau to acquaint the public with their value. Samples of dehydrated foods were sent to hotels, hospitals, schools, clubs, and restaurants for personal test, with the request that the results be reported. Replies received by the bureau indicate that the dehydrated products were considered satisfactory and the campaign gave very encouraging results. A large number of letters requesting specific information concerning dehydration were received, and appropriate information forwarded. A number of popular articles were prepared for publication in journals, magazines, and newspapers.

During the year 1920-21 the following reports were submitted for publication: "The Mineral Constituents of Potato Flour: Effects of Process of Manufacture on Composition of the Ash of Potato Flour," "Effect of Heat on Different Dehydrated Vegetables," "The Manufacture of Sweet Potato Flour by the Flake Process," "The Relation of Moisture Content to the Deterioration of Raw-Dried Vegetables upon Common Storage," "Methods of Preparing Vegetables for Dehydration—Potatoes, Carrots, and Cabbage," "Sun Drying Versus Dehydration."

THE PROTEIN INVESTIGATION LABORATORY.

For some time it has been known that only certain proteins are capable, unsupplemented, of furnishing all the necessary nitrogenous constituents of the diet. Others must be supplemented by the addition of those ingredients in which they are deficient, if they are to be utilized efficiently by animals. It is therefore of great economic importance to know in what manner a given protein is deficient in order that in feeding animals its deficiencies may be compensated for and wasteful methods of feeding avoided. Such knowledge which has been lacking for many of the most important food proteins is now available in the protein investigation laboratory. Since its establishment in 1915 this laboratory has put out 33 scientific communications bearing upon this general subject.

Among the proteins studied are those of barley, kafir corn, the peanut, buckwheat, several species of beans, and tomato seed. Incidentally, the methods of making such studies have been improved. Information thus obtained has been applied in feeding experiments either upon laboratory animals or, in cooperation with the Bureau of Animal Industry, upon farm animals. The reasons why some of

these foodstuffs are not satisfactorily utilized have been disclosed and the remedy shown in a number of instances. For example, it was found that, while the protein of wheat flour is not very satisfactory in promoting growth, bread made from a mixture of 15 parts of soy bean meal and 85 parts of wheat flour furnishes protein and water-soluble vitamine adequate for normal growth. Certain other materials, for example, peanut meal, may be used instead of the soy bean meal. For somewhat similar reasons ordinary beans are not a very satisfactory source of the necessary nitrogenous elements of diet. However, if cooked and supplemented with the sulphur-containing substance cystine, or a protein containing much cystine, they become an excellent source of food protein. Similar studies have been made upon the best methods of supplementing such important feedstuffs as corn and corn gluten.

In addition, the protein investigation laboratory has studied the effect upon animals of the addition to the diet in minute quantities of certain heavy metals that may contaminate ordinary foods—information of service in the enforcement of the food and drugs act.

During the current year the laboratory has presented or has sent to press the following reports: "The Nutritive Value of Peanut Flour as a Supplement to Wheat Flour," "Some Amino Acids from the Globulin of the Coconut as Determined by the Butyl Alcohol Extraction Method of Dakin," "Hydrolysis of the Globulin of the Coconut," "Some Proteins of the Mung Bean, *Phaseolus aureus*," "The Globulin of the Cohune Nut," "The Effect of Cooking on the Digestibility of Phaseolin," "The Nutritive Value of Soy-Bean Flour as a Supplement to Wheat Flour," "The Nutritive Value of the Proteins of the Lima Bean," "The Nutritive Value of the Proteins of the Adzuki Bean," "The Basic Amino Acids of Glycinin, the Globulin of the Soy Bean, as Determined by Van Slyke's Method," "The Nutritive Value of the Proteins of Tomato Seed Press-Cake."

Work upon the effect of small quantities of cadmium in the diet and upon the nutritive value of the proteins of the Chinese and Georgia velvet beans has been completed.

In progress is an investigation on the composition of the milk protein, lact-albumin, of the two globulins of the Adzuki bean, of the proteins of the navy bean, the palm kernel, and the Lima bean, and of the globulin of the soy bean. An attempt is being made to explain why arachin, the chief protein of the peanut, does not produce satisfactory growth in rats when fed as the sole source of protein and why the nutritive efficiency of the proteins from the Chinese and Georgia velvet bean depends in part upon the method of preparation.

Among the investigations upon nutrition now engaging the attention of the laboratory the following may be mentioned: Work upon the cowpea, *Vigna sinensis*, indicates that cooking and the addition of cystine are necessary to render this food adequate for the normal growth of albino rats. With the ordinary pea, *Pisum sativum*, however, it is probable that growth can be obtained when it is fed cooked or uncooked with the other nonprotein dietary ingredients. Cystine is not required, as in the case of the seeds of the genus *Phaseolus*. It is of interest to note that of the genus *Phaseolus* the Adzuki bean is the only seed so far studied which is well utilized without cooking, although addition of cystine was necessary before its proteins were

available for normal growth. The nutritive value of the press cakes from peanuts, soy beans, tomato seeds, and coconuts as supplements to corn is being determined by a series of feeding experiments. Results indicate that when 25 per cent of certain of these concentrates is added to corn, the rate of growth is normal.

THE PHYTOCHEMICAL LABORATORY.

The phytochemical laboratory, established in 1916, has been ascertaining the nature of the chemical substances which impart to some of the edible fruits their peculiar aroma, of which until recent times practically nothing was known. In the absence of such information many of the forms of adulteration of natural fruit juices and artificial flavoring materials can not be controlled. The first investigation of this kind conducted here was with apples. On the basis of the results obtained a public service patent has been granted for the production of a "synthetic apple oil," which contains only such substances as have actually been found in the apple. This may find useful application for flavoring purposes. Other work along this line has been undertaken, notably in connection with the odorous constituents of peaches. A method for the detection of methyl anthranilate, a chemical substance suspected of being used as an artificial flavor in grape products, has been devised. An investigation is in progress to determine whether methyl anthranilate is a natural constituent of different kinds of grapes.

In collaboration with other branches of the Department of Agriculture, this laboratory conducts chemical investigations upon such plants or plant products as are deemed to be of medicinal or economic importance. For example, when during the World War a caffeine famine threatened, it made a survey of the North American *Ilex* species and determined that *Ilex vomitoria*, which occurs more or less abundantly along the coast from Virginia to Texas, contains in its leaves an appreciable amount of caffeine. Further attention was directed to another hitherto unknown source of caffeine, the pulp of the coffee berry, millions of pounds of which become available every year in Porto Rico and other coffee-producing countries.

THE LEATHER AND PAPER LABORATORY.

The leather and paper laboratory is concerned with those agricultural products which are utilized by the leather, paper, and naval stores industries, and also investigates the waterproofing, mildew-proofing, and fireproofing of fabrics for farm and other uses and the utilization of wool-scouring wastes. Its only regulatory work is an occasional examination of turpentine sold for drug purposes.

NAVAL STORES.

The object of its naval stores (turpentine and rosin) studies is to improve methods of production, eliminate wastes, develop better methods of handling, storing, shipping, and testing, including accurate grading and weighing, to prepare specifications, to discover new uses or improve the adaptation of these materials to regular uses, and to furnish information on annual production and stocks in the hands of producers, dealers, and consumers.

As is generally known, rosin is sold by grade which is determined by the color and the presence of dirt. Up to March, 1914, there were no objective standards for grading rosin. The grading samples used were made of rosin and therefore were subject to rapid changes in color, especially when used in or exposed to sunlight. Inaccuracy in grading was exceedingly frequent and misgrading particularly prevalent when the Bureau of Chemistry began a systematic study of the subject, which resulted in the development of permanent glass types made to match the grades long recognized in the trade, put up in precisely the shape of the regular rosin-grading types the trade had been using and capable of being handled in the same way. These permanent glass types were approved and adopted by all boards of trade and chambers of commerce of the primary naval-stores markets of this country, and sets of them have been deposited at all of the naval-stores trading centers in the United States and at one point in England (London), where they are accessible to the industry. Furthermore, since 1915 all grading samples made of rosin have been made to match the permanent glass rosin types. Thus, very simply and without disturbance of trade practices, the bureau has substituted definite, permanent grading types for the indefinite changeable types formerly used. Related to the work which led to the introduction of objective rosin grades is the investigation now in progress to determine the constants and composition of rosins from different kinds of timber or of rosins of different grades.

There has been but little improvement in turpentine still practice and in packing, handling, and trading in turpentine and rosin since the early days of the industry, in the case of the smaller operators. During the seasons of 1915, 1916, and 1918, therefore, field parties from the bureau studied thoroughly the operations of more than 500 stills and made suggestions and recommendations for improvement in the equipment and processes. Decided betterment in the industry has resulted from this demonstration work, which later was supplemented by forceful posters and circulars, all aiming to drive home the lesson of better and more economical working, as well as the value of combining naval stores production with farming to the extent of raising foods for the animals and, as far as feasible, for the laborers employed. In this connection a study was also made of production costs and the information thus secured is serving as the foundation for a simple system of accounting to enable the smaller operator especially to know more definitely the exact condition of his business.

Better grades of rosin bring a much higher price than the lower grades. Heretofore this difference in value between grades below "G" and those above "WG" has been anywhere from \$1 to \$2 a 280-pound barrel. For various reasons many producers do not succeed in making the higher grades. In fact, the making of only high-grade rosin by the small producer is hardly practicable with present methods. It has long been the practice, especially in France, to convert the lower-grade rosin into a higher grade by exposing the product in very shallow pans to the sunlight, which bleaches out the color. As this procedure is not at all suited to the American industry, a more rapid and acceptable method was sought, resulting in the distillation of rosin under a high vacuum. This can be done without much decomposition, with the production of rosin better than XX from

"A" or "B" grades. The yield varies from 60 to 80 per cent of undecomposed rosin, and there is reason to believe that the higher figures can easily be obtained in practice. A public patent has been granted on this process, but it has not been developed industrially, primarily because during the war the difference in price between low and high grades was not sufficient to warrant it. The procedure, however, is available for development on the industrial scale whenever conditions warrant, and also is serving the bureau as a means of studying rosin and the decomposition products resulting from improperly controlled distillation by the ordinary procedure.

The use of rosin in making varnishes has been steadily increasing, until it is now known to the industry that varnishes made from the so-called rosin esters are more durable and less brittle than those made from unmodified rosin. Rosin esters are obtainable on the market, but are not always uniform, nor are the results obtained with them always entirely satisfactory. With the view to developing the best methods for the production of a uniform product, investigations on the preparation of rosin esters have been inaugurated during the year.

The methods of making wood turpentine have changed materially within the past 10 years. The demand for pine oil and other heavy oils for use in the flotation of minerals has led to the more careful refining of wood turpentine to extract from it all of the heavier oils which can be classified under the general term of "pine oil." Furthermore, the use of petroleum oil solvents has increased and there are now on the market a number of wood turpentines which are made by the solvent extraction process. In the preparation of interdepartmental specifications for the purchase by the Government of turpentine and in the preparation of specifications for the American Society for Testing Materials, specifications on which most of the turpentine bought by the larger consumers is purchased, information on the constants of present-day wood turpentine was found necessary. Samples of the regular stocks of the various makes of wood turpentine, both steam and destructively distilled, and also fractions of these turpentines taken during the refining distillation of the crude-wood turpentines, have been examined to establish their constants and their content of mineral oils. The results of this investigation are now being prepared for publication.

A practical method for refining wood turpentine, which involves the preliminary boiling, under a reflux condenser, with a sodium carbonate solution, followed by the distillation of the turpentine, has been thoroughly worked out. Boiling the crude turpentine with sodium carbonate solution resinifies certain objectionable light oils to which the strong odor of many wood turpentines is primarily due, and insures their elimination on subsequent distillation. A study on an industrial scale of the distillation of resinous wood under definitely controlled temperature conditions has been made.

Until within the last few years the detection and determination of small quantities of mineral oil in turpentine has been difficult and uncertain. In fact, no method could be relied on to detect less than 10 per cent of mineral oil, and adulterators had become so expert that even as little as from 2 to 5 per cent was frequently added at a profit. Undertaking to correct this condition, the bureau worked out a quick, easy, and certain method for detecting and determining

mineral oil in turpentine, which has been adopted as the standard throughout this country, and is included in the interdepartmental, American Society for Testing Materials, and Pharmacopœia specifications for turpentine. In addition, a reliable method for the detection and estimation of added coal-tar oils in turpentine has recently been developed. An accurate method for the determination of acetic acid in pyroligneous acid has been evolved, while a study resulting in the improvement of the method for the determination of methyl alcohol in pyroligneous liquors has been concluded.

For the past eight years the bureau has kept in close touch with the old practice, unfortunately not yet abandoned, of misgrading rosin and adulterating turpentine. In many instances more than 50 per cent of the rosin in a shipment had been misgraded and from 20 to 25 per cent of all the samples of turpentine which the bureau has examined were adulterated with mineral oil. Against these practices neither the producer nor the smaller ultimate consumer has the least redress, and after careful consideration the bureau has concluded that they can not be eliminated without Federal legislation.

In the matter of the grading and analysis of turpentine and rosin, pitches, and materials related thereto, the laboratory has continued to cooperate with the supervising inspectors of naval stores of Georgia, Florida, and the New York Produce Exchange, with the Turpentine and Rosin Producers' Association, with the National Oil, Paint, and Varnish Manufacturers' Association, and with the American Society for Testing Materials. In a few instances, when it could do so without becoming entangled in a controversy and when requested by both parties to the transaction, the bureau has acted as referee in disputes as to the purity of shipments of turpentine and the correctness of the grading of deliveries of rosin. It has followed this course only in such instances as promised to furnish information of value to the bureau in its naval stores research work.

Except for the decennial census figures and the statistics on the receipts and stocks at the primary naval stores ports, Savannah, Ga., and Jacksonville and Pensacola, Fla., no definite figures or information concerning the annual production and stocks of turpentine have been accessible. The result has been a widely fluctuating market, detrimental to producer and consumer alike. At the urgent request of the industry, therefore, the bureau began the collection of statistics of production and stocks in the hands of producers, dealers, and consumers in 1918, and has issued these semiannually since that time. It has been necessary also to compile a complete list of turpentine producers and one of the prime consumers of turpentine and rosin, both of which have been much sought by the industry. The list of producers served the Bureau of the Census as a guide in making its 1919 census of production. As soon as issued the reports are distributed to the public press and a copy is sent to each producer and consumer on the bureau's lists.

One of the big problems of the far Northwest is the clearing of land for agricultural purposes. As a large proportion of this land is cut-over western yellow pine, it seemed possible that the expense of clearing this land might be met, in part at least, by some method of utilizing the stumps of these trees. In an investigation, undertaken in cooperation with the forestry department of the University of

Idaho, two years were devoted to a study of the yields obtainable by destructive distillation from the western yellow-pine stumps of Idaho and Washington. The general conclusion was drawn that in certain localities many stumps in ordinary times can be profitably used in the production of wood turpentine, pine oil, tars, and charcoal, thus affording some return to the homesteader for this otherwise useless material that must be removed before he can get his land in final shape. Detailed results of the work will soon be published as Department Bulletin 1003.

During the year Department Bulletin 898, "Turpentine, its Sources, Properties, Uses, Transportation, and Marketing with Recommended Specifications," was published. The first edition was entirely exhausted within three months, making it necessary to prepare a revised edition to meet the demand.

TANNING AND LEATHER.

Research upon tanning and leather is one of the old, long-established lines of investigation in the Bureau of Chemistry. Work of this type has been done in the Department of Agriculture from the time of its establishment. The project assumed such importance that a special laboratory, the dendro-chemical laboratory, was established for it and related work in the organization of which the Forest Service and the Bureau of Chemistry cooperated. At the close of this cooperation the work was continued without interruption in the leather and paper laboratory, organized in July, 1904, by direction of Secretary Wilson. No technical investigations have a more intimate relation to agriculture than leather and tanning studies, since the material used in tanning originates on the farm and range and in the forest, the leather industry furnishes the farm business with one of its important markets, farmers as a class are the largest users of the finished articles made by the tanner and the manufacturer of leather goods, and finally, the materials and the process of the tannery are very largely biological.

Already the country is importing almost half the hides and a large percentage of the tanning material it uses. If it is to maintain permanently its preeminence in the leather industries, methods must be devised for the manufacture of better leathers at the lowest cost, for the better utilization of native tanning materials and hides and possibly for the creation of a synthetic tanning materials industry, probably not an achievable goal for the modern science of organic chemistry. Although tanning is one of the oldest of the arts, most of it is still done by rule of thumb methods. Science, instead of pointing the way, is still far behind practical experience. If science is ever to lead the way in this industry, many separate sciences must be focused upon its problems—agriculture, zoology, botany, microbiology, analytical, organic, and colloid chemistry, and, to some extent, engineering. Of all the Government services the Department of Agriculture alone now employs a considerable body of experts in each of these branches.

The tanning and leather work of the Bureau of Chemistry includes investigations on the handling of hides, on the sources of tanning materials, on the processes of leather making, on the recovery and utilization of tannery and leather wastes, and on the

properties and uses of leather and leather substitutes, leather dressings, and finishing and treating materials.

There is a tremendous aggregate loss in hides and skins through ignorance of the proper methods of handling "country" hides and skins. As a matter of education, Farmers' Bulletin 1055, "Country Hides and Skins: Skinning, Curing, and Marketing," was issued, in cooperation with the Bureau of Animal Industry and the Bureau of Markets. Supplementing this bulletin, an interest-arousing poster, "More Money for Better Hides," was prepared. New editions of both became necessary within a few months. To promote the educational campaign thus started and to drive the lessons home, the office of exhibits displayed defective sides and sections of leather at the various State fairs and the International Live Stock Exposition in Chicago.

For the past several years there has been a growing interest in tanning on the farm or on a small scale, probably due to the fact that the farmer or small producer of hides and skins gets very little for them and must pay relatively high prices for the leather articles he buys. Despite much urging that the bureau issue instructions for tanning on a small scale, it has not felt justified in doing so, partly because of the lack of reliable information on small-scale tanning and partly because of the probability of frequent failures on the part of inexperienced persons who attempt small-scale tanning. Work looking to the ultimate development of suitable methods for small-scale operations has, however, been undertaken. Directions for making alum-tanned lace leathers already have been issued. In the meanwhile advisory leaflets of the nature indicated by the following titles have been distributed: "Note on Salting and Curing Hides on the Farm"; "Information on Having Hides Tanned," together with a list of tanners who have written the bureau that they tan leather and furs for farmers; and "Buying Leather by the Side."

As domestic supplies are growing inadequate, numerous investigations of various materials as possible sources of tannin have been made. Among these may be noted foreign woods and barks, samples of which have been analyzed for the office of foreign plant introduction, willow bark, waste hemlock, domestic nut galls, saw palmetto roots, and paper-mill waste spruce and fir barks. Willow barks contain enough tannin to be valuable if sufficient quantities can be brought together at a low cost. Paper-mill waste spruce bark contains enough tannin to warrant further study, provided it is feasible to separate it in the mill from the fir bark which contains but little tannin and imparts an objectionable color to leather. Perhaps the most abundant incompletely utilized domestic source of tannin is sumac. The Bureau of Chemistry has attempted to stimulate the gathering and use of this abundant wild plant, issuing in this connection Department Bulletin 706, "Sumac: A Valuable Tanning Material and Dyestuff," a new revised edition of which became necessary this year. Examinations of commercial leathers indicate that a good deal of the leather on the market contains excessive quantities of uncombined tannin, representing a waste of but little less than \$1,000,000 worth of tannin yearly.

In many instances tanners and others have received help, three examples of which may be cited. A number of tanners were shown

that in their plants the tan bark was being extracted so poorly that more than half the tannin normally present remained in it. In co-operation with the Bureau of Animal Industry, assistance was tendered to some northern tanners in determining the character of a peculiar defect of certain skins, which was not apparent until the skins were split. The trouble was found to be due to follicular mange, and suggestions were given to aid in recognizing such defective skins before splitting, thereby conserving many skins suitable for certain kinds of leather but almost an entire loss if used for split leather. Difficulties in unhairing some hides were shown to be due to curing with salt containing alum, which set the hair by a partial tannage. A news note of warning against the use of such salt was given wide publicity.

With a view to helping to mitigate public nuisances and to recover all possible by-products, many samples of tannery liquors, wastes, and recovered products have been analyzed to learn their value, usually for fertilizer purposes. Procedures advocated by the bureau have been worked out successfully on a commercial scale. Two articles, "The Purification of Tannery Effluents" and "The Purification of Tannery Effluents and the Recovery of By-products Therefrom," summarize the best available information.

Much work was done, especially during the war, in determining the efficacy of waterproofing compounds for leather. The laboratory aided the War Department in the selection of the best from among the materials submitted and in the preparation of specifications for their purchase. Furthermore, several original formulae were devised for the waterproofing of sole and upper leathers.

Scientific investigations of chemical processes of manufacturing are possible only if exact quantitative analytical methods are available, by means of which the various stages of the process can be followed and the character of the final products determined. The chemical nature of the materials and processes of the tannery are so little known that correct methods of analysis are comparatively few. The leather and paper laboratory has devoted much attention to the development of such methods. The official method of the American Leather Chemists' Association for glucose in leather is this laboratory's work. A fluorescence test for oak bark has been elaborated to determine the use of this bark in the preparation of tanning extracts and leather. Other papers dealing with analytical methods have been published under the following titles: "Free Sulphuric Acid in Leather," "The Preparation of Heavy Leather Samples for Analysis," "The Solvent Action of Petroleum Ether and Chloroform on Leather Stuffing, Oils, and Greases," "Kaolin for Tannin Analysis," "Epsom Salts in Leather," "The Determination of Moisture in Leather," "The Extraction of Oils, Greases, and Soaps in Leather," and "Comparison of the Gravimetric and Volumetric Determination of Epsom Salts in Leather."

Work on the determination of glucose and Epsom salts was done in connection with the study of the practice of "weighting" or "loading" heavy leathers sold by weight, particularly sole leather. To ascertain the extent of this practice, some years ago a representative number of commercial sole leathers were examined. Of these 63 per cent were weighted with Epsom salts or glucose, or with both. These findings, published in Bureau of Chemistry Bulletin 165, "Leather

Investigations," evoked criticism which is believed to have had a salutary effect.

The identification of the kind of skin from which a given finished leather was made is often important in detecting imitations. The hair hole formation and distribution are characteristic for different kinds of skins. A procedure for photographing wax impressions of this formation so as to bring out detail and contrast has been evolved.

As necessary as reliable analytical methods in studying scientifically the materials and processes of leather production are accurate service tests for the finished leather. No other method can furnish equally reliable information concerning the suitability of a leather for the use for which it is destined. In fact, progress in developing processes for increasing the wearing quality of leathers, especially sole leathers, will be seriously hampered until some means of quickly and accurately proving or determining the relative value of proposed improvements has been obtained. The Bureau of Chemistry was probably the first to scientifically approach this problem which has since aroused the interest of others. A series of machines for determining quantitatively the wearing quality of sole leather have been constructed, and the data thus obtained have been made public. In spite of some notable progress, however, the development of mechanical serviceability tests is still in its infancy. In solving this problem it is necessary to check the mechanical wearing experiments against extensive actual wearing experiments. Such tests have been made by the bureau with boy scouts, with civilians, and with infantry.

Of as great importance as the more economical production of better leather is its more rational use. The bureau has endeavored to bring this about in two ways, by educating users and by studying the factors that cause leather to deteriorate. Information on this subject has received the widest publicity, largely through Farmers' Bulletin 1183, "The Care of Leather," which is being used after the manner of a textbook by several institutions.

It is essential that certain leathers have a long life, as, for example, those for bookbinding and upholstering. This laboratory and others proved sulphuric acid, which formerly was quite freely used at certain stages of the manufacturing process, to be very injurious. Progressive tanners, having been brought to a realization of this fact, are making appropriate modifications of their processes. Of even greater importance for belting, strap, and harness leathers is the effect the various oils and stuffing materials may have upon the leather. In studying this problem, however, the laboratory found that the fundamental conditions for obtaining quantitative strength tests must first be worked out, since preliminary results indicate that relative humidity and possibly temperature materially affect the strength of leather.

Throughout its history the laboratory has done work for and cooperated with other Government agencies and with such associations as the American Leather Chemists' Association and the Association of Official Agricultural Chemists. At one time it conducted a good deal of routine testing of Government purchases, but this has been turned over to other agencies in order to permit it to devote all its resources to constructive work. During the war assistance was given the War Department, especially on bag, strap, harness, upper and

sole leather, in determining the suitability of certain leathers for special purposes, in the physical testing of leathers, and in ascertaining the efficacy of finishing materials and treatments. Advice was given the War Department, the Council of National Defense, and the War Industries Board in drawing up and revising specifications for leather. Members of the laboratory have often acted in an advisory capacity for other agencies of the Government, such as the Panama Canal Commission, the Tariff Commission, the Treasury Department, the General Supply Committee, and the Federal Trade Commission. In connection with studies by the Bureau of Plant Industry on the chestnut blight, samples of chestnut bark from blight-resistant and nonresistant trees were analyzed for tannin and other constituents. At the request of the Interior Department, methods used for tanning alligator skins have been surveyed and a full report made to the Indian Commission which contemplated the establishment of this industry among the Indians of Florida.

WATERPROOFING, MILDEWPROOFING, AND FIREPROOFING FABRICS.

For years the Department of Agriculture has been asked by farmers for information on the waterproofing, mildewproofing, and fireproofing of cotton duck to be used out of doors for wagon, stock, shock and hay covers, for tents, paulins, awnings, etc. Work to secure the information demanded was begun in 1916. Called upon to assist the War Department in testing the character and the effectiveness of various waterproofing treatments for canvas, the bureau was charged with all the work of this nature during the continuance of the war.

Several mold species considered representative of those causing the mildew of canvas have been identified and used in the laboratory work in the determination of the mildew resistance of various mildewproofing processes.

The following publications on the waterproofing and mildewproofing work have been issued: Farmers' Bulletin 1157, "Waterproofing and Mildewproofing of Cotton Duck;" "The Determination of Water Resistance of Fabrics;" "Testing the Mildew Resistance of Textiles;" and "The Water Resistance of Treated Canvas During Continuous Exposure to Weather."

Some time has been devoted to a study of methods for fireproofing canvas fabrics for outdoor use, especially in cooperation with the War Department, in a search for a water-resistant fireproofing treatment, particularly for camouflage purposes. Many experiments were made with numerous treatments, including those usually recommended, but up to the present time no fireproofing treatment has been found which is weatherproof.

WOOL-SCOURING WASTE.

Approximately 600,000,000 pounds of raw unscoured wool are used in this country annually. Unscoured wool shows approximately a loss of 40 per cent in scouring, this loss consisting of dirt, suint, and grease. The grease content averages around 15 per cent, while the potash (K_2O) averages about 4 per cent. On the basis of these figures, unscoured wool contains about 90,000,000 pounds of wool grease, and 24,000,000 pounds of actual potash, annually. If converted into lanolin and refined wool grease, large quantities of which

are used in this country as a basis of ointments and cosmetics and for medicinal purposes, the wool grease would more than supply all domestic needs. A small quantity of the wool grease, which has long gone to waste in this country, is now being recovered, but all the potash, which is greatly needed for agricultural purposes, is still contributing to the pollution of streams. In 1918 the importance of the matter was laid before Congress, which has appropriated annually \$9,000 for the study of this problem.

In addition to the grease and potash, a small percentage, usually less than 1 per cent, of nitrogenous material is removed from wool by scouring. Concentrated wool-scouring waste, from which the greater part of the grease had been removed, was mixed with various regular fertilizer materials, such as acid phosphate, steamed bone meal, and leather scrap, and in every instance found to yield a mixed fertilizer of excellent texture, with the potash water soluble and the availability of the other constituents unreduced. Experiments on the industrial scale indicate that it may be profitable to take these offensive wastes out of the country's watercourses by using them in the manufacture of fertilizers, thus returning to the farm a part of the fertilizer constituents removed in the raw wool.

The bureau is cooperating with wool scourers in improving the methods of recovering and utilizing the grease and potash and especially in improving the methods of refining the crude grease. Methods devised in the laboratory are now being developed on an industrial scale in a wool-scouring plant. Ordinary wool grease is used chiefly in the leather industry, in cordage and printing inks, and for the manufacture of lanolin. The laboratory has found that when properly refined it is particularly valuable for currying leathers and waterproofing canvas.

PAPER.

In 1913, the investigations on paper and paper-making materials had long been in progress; in fact, this was among the oldest and best established lines of technical work of the bureau, which was regularly called upon by the several departments, especially by the Government Printing Office, to pass upon deliveries of paper. After this work had long been in progress the Bureau of Standards began the testing of papers, with the result that two Government agencies were engaged in the testing of deliveries of paper for the Government departments. Though the two bureaus were serving in the main different governmental agencies and therefore not testing the same deliveries, it seemed uneconomical to the Bureau of Chemistry to have the work thus divided. Therefore, though not responsible for the situation, the Bureau of Chemistry in July, 1914, brought about the transfer of this and certain other testing of deliveries for the Government departments, together with the appropriate funds, to the Bureau of Standards. Since that time, so far as possible, it has devoted its efforts, in cooperation with the Forest Service, to the study of the serviceability and durability of paper, paper-making materials, and related matters.

Specifications which are the basis for all purchases of paper made by the Federal departments, and which have been followed extensively by other large users of paper, have been prepared. For 10 years or more the bureau has served the Joint Committee on Print-

ing of Congress, the General Supply Committee, the Navy Department, the War Department, Post Office Department, and other Government departments in the preparation of specifications for paper for various purposes. This work has produced many results, not always tangible, including a more intelligent and fair competition in bidding on Government supplies, more uniform delivery of specified papers, the use of paper better suited for the purpose in hand and the more economical and conservative purchase of paper. Savings of many thousands of dollars annually in the purchases of the Government Printing Office, the Post Office, and other departments have resulted from the use of more suitable and lighter papers based on the tests and recommendations made by the Bureau of Chemistry.

Investigations on blue and brown print paper, including the devising of an economical method of preparing potassium ferricyanide, have resulted in the establishment of the manufacture of such papers in this country. Government engineers and others can now procure here all the blue print paper needed and of a quality superior to that formerly obtained from abroad. Methods devised for testing blue print paper have made it possible for any purchaser to specify rigidly and to secure the quality of paper suited to his needs. As a result of the investigations on blotting paper, the Government has adopted much lighter weight paper for blotting purposes, thus effecting a saving of from 40 to 60 per cent in cost. A method, which is simpler, more easily executed, and more uniform than those heretofore commonly employed has been developed for the testing of blotting paper.

At the request of the Bureau of Engraving and Printing, cooperative work has been conducted on the effect of relative humidity on currency paper and the processes of engraving, sizing, and finishing.

At the request of the Navy Department, specifications based on actual service tests were prepared during the war for a special reinforced type of fiber container to be substituted for the wooden box in the overseas shipments of canned goods. This necessitated the designing and construction of a new testing machine known as the impact tester.

Work was done for the War and Navy Departments in the development of a strong water-resistant paper for wrapping bales for overseas shipment. Specifications for such paper were prepared and methods of testing it were developed.

Assistance was given the War Department in determining the moisture resistance of fiber containers offered for powder charges to be used in the larger guns.

The investigations on the water resistance of fiber boards and adhesives used in the manufacture of solid and corrugated fiber and wall boards have greatly stimulated the interest of the industry, especially in the effects of these adhesives upon the board and its water resistance, and in the value of proper rosin sizing of the board to increase its water resistance. Following the work which the bureau did on these subjects, fellowships were established by the industry at educational institutions to investigate further these technical problems, while greater economy in the use of adhesive and increase in the durability and water resistance of the board have followed. The deteriorating effect of certain adhesives has been shown, and methods

for reducing such effects have been devised. New adhesives discovered by the Bureau of Chemistry are being studied.

From the beginning of its active paper work the Bureau of Chemistry has contributed much to the origination and improvement of methods and apparatus for testing. It originated the standard methods for determining the fiber composition of papers, a method now almost exclusively used by commercial and mill testing laboratories. It developed a standard method for the determination of rosin size, for the determination of the absorption of blotting paper, for testing blue and brown print papers to ascertain their durability and serviceability, for the determination of the translucency of paper, the degree of sizing, and resistance to moisture. It has greatly improved one of the generally used strength testing machines, making it more accurate and rapid. It has developed a machine for testing fiber board and the methods for expressing the strength factor of paper. It installed and has operated for 12 years the only constant humidity and temperature room which is known to be in actual operation.

Twenty-four publications have so far been issued, and the work for four others has been completed.

THE INSECTICIDE AND FUNGICIDE LABORATORY.

The work of the insecticide and fungicide laboratory consists in: (1) The examination of insecticides and fungicides, including disinfectants, for the Insecticide and Fungicide Board; (2) the examination of insecticides and fungicides for the bureaus of the Department of Agriculture, particularly the Bureau of Entomology and the Bureau of Plant Industry, and for other departments of the Government; (3) investigation and research in connection with the production, properties, and application of insecticides, fungicides, and related products, in cooperation with the Bureau of Entomology and Bureau of Plant Industry, studies on the effect of insecticides and fungicides on plants and the contamination of the sprayed products from the standpoint of the consumer, and the development of new insecticides and fungicides and the study of their properties; (4) research upon appropriate standards for insecticides and fungicides, upon adulterants and the means of detecting them, and upon the methods of analyzing insecticides and fungicides.

EXAMINATION OF INSECTICIDES AND FUNGICIDES.

Under the first two items the laboratory has analyzed since 1913 more than 10,000 official samples of insecticides and fungicides, including disinfectants, for the Insecticide and Fungicide Board, and more than 4,000 samples of insecticides and fungicides and related products for other bureaus of the department. Several thousand other analyses have also been made in connection with the research work of the laboratory.

INVESTIGATIONS ON INSECTICIDES AND FUNGICIDES.

The principal activities embraced under the third heading are: An investigation of the toxic effect on fruit trees of certain constituents used in insecticides, particularly copper and arsenic, to determine whether or not the continued use of insecticides or fungi-

cides might ultimately result in a serious accumulation of these toxic substances in the soil and cause injury to trees or plants through absorption of poison by the roots. Several new lead arsenates and lead chlor arsenates were prepared and their properties determined. The cause of injury to foliage by di-lead arsenate was found to be due, in many cases, to its decomposition by salts that occur naturally in the waters which are used in its application. It was also shown that di-lead arsenate is decomposed by pure water alone, although this action is extremely slow. The final products of decomposition are arsenic acid and a basic lead arsenate. This work is of value in showing how injury may occur when treated foliage is subjected to the frequent action of light rains, fog, or dew. Field and laboratory experiments to determine the effect on foliage of Paris green containing varying amounts of soluble arsenic and the development of a laboratory method by which this can be determined have been conducted.

In cooperation with the Federal Horticultural Board, a method of fumigating cotton bales with hydrocyanic acid gas, to guard against the introduction into this country of the pink boll worm, was devised. Cooperative experiments have also been carried on to devise methods of fumigating foodstuffs, such as seeds, milled grains, vegetables, fruits, etc., in order to destroy insect life without rendering the food unfit for human consumption. A study of larvæcides for preventing the development of the house-fly larvæ in horse manure resulted in the discovery of useful methods for the control of this pest. In cooperation with the Bureau of Entomology, an investigation to determine whether or not honey bees are killed by feeding on blossoms of trees that have been sprayed with arsenicals was made.

More than 3 tons of a new tree-banding material here developed were made in the laboratory for the experimental use of the Bureau of Entomology in its work to control the gypsy moth in Massachusetts. This material proved so satisfactory for this purpose that many tons are now used annually in commercial control work. It is superior to and can be prepared at a much lower cost than anything previously on the market for the same purpose.

An investigation of the calcium arsenates has been made and several new calcium arsenates have been prepared and their properties studied, some of the results of which appear in Department Bulletin 750, "A Method of Preparing a Commercial Grade of Calcium Arsenate." A method for the commercial preparation of calcium arsenate has been developed and a patent covering the process has been dedicated to public use.

In an investigation on the toxic action of certain gases on insects, seeds, and fungi, made in cooperation with the Bureau of Entomology, the action of phosgene, arsine, cyanogen chloride, chloropicrin, illuminating gas, and carbon monoxide were studied. Cyanogen chloride and chloropicrin gave promise of being useful for fumigating purposes. Neither, however, can be used in greenhouse fumigation on account of their injurious action on plants. The results of this work were published as Department Bulletin 893, "Experiments on the Toxic Action of Certain Gases on Insects, Seeds, and Fungi."

An investigation upon Pickering sprays and other copper Bordeaux mixtures, carried on in conjunction with field experiments for four

seasons, gave much valuable information which is published in Department Bulletin 866, "Pickering Sprays."

A study of the toxicity of various arsenical preparations on insects has been under way for two years. This work will be of much practical benefit in connection with the use of insecticides.

Department Bulletin 989, "Pine-Oil and Pine-Distillate Product Emulsions," contains many chemical and bacteriological data and shows that pine-oil emulsion disinfectants are of very limited practical value, in that they are ineffective against some of the common pathogenic organisms. These emulsions, however, deteriorate but little with age, which is contrary to several statements published.

The laboratory is cooperating with the Bureau of Entomology in connection with its work at Riverton, N. J., to discover a method of controlling the Japanese beetle, which has become established there. Work in connection with the control of flies on live stock is being carried on in cooperation with the Bureau of Entomology branch laboratories at Dallas and Uvalde, Tex.

During 1917 and 1918, chemical investigations of the foliage of trees sprayed with lime-sulphur and copper sprays, with and without stickers, were made for the Bureau of Plant Industry to determine the effectiveness of stickers, as well as the sticking qualities of various copper and sulphur sprays. Investigations on the formaldehyde content of solutions used in treating certain grain smuts were made for the Bureau of Plant Industry. Investigations on the chemical and physical composition of mineral oils used in citrus spraying work were made for the Bureau of Entomology. Suggestions as to promising substances to use against bark and wood boring insects were made to the Bureau of Entomology and certain new mixtures prepared for test. Aid was also given to the Bureau of Entomology in the matter of certain insecticides used to combat the boll weevil.

The laboratory has examined many materials that gave promise of being valuable as insecticides or fungicides. The majority of these were vegetable products. Recently it has undertaken a study of the synthetic organic compounds with a view to discovering new valuable active substances. Among other compounds many pyridine and piperidine derivatives have been studied.

STANDARDS.

Researches carried on under the fourth heading are: An investigation to determine the amount of pyrethrum stems and sand in insect powders and establish allowable limits for these two ingredients, and one on the active principle of insect powder and methods for its determination; a study of the adulteration of insect powder with powdered daisy flowers and methods for determining this form of adulteration; an investigation on the occurrence of manganese in insect powder, the presence of which, it had been claimed by certain authors, was an indication of adulteration, demonstrating that manganese occurs in both stems and flowers and in greatly varying amounts, depending apparently upon the nature of the soil in which the plant is grown; an investigation of the method of production and composition of tobacco dusts sold on the market, undertaken primarily for the purpose of establishing standards for this product;

work on methods for the determination of alkaloids in hellebore, and an investigation on the amount of acid-insoluble ash in this material, for the purpose of establishing standards for powdered white hellebore, which have given much valuable information.

It has been claimed that commercial dry powdered calcium arsenate, containing lime in excess, undergoes decomposition on standing in the package, resulting in the production of water-soluble compounds of arsenic. This question is being investigated. Large samples of a number of commercial brands of calcium arsenate have been stored in different localities in various types of packages, and samples from them examined at definite intervals. The result of this work, which is nearly completed, indicate that very little, if any, deterioration occurs. At least it is not sufficient, during any reasonable time of storage, to be of practical importance.

METHODS OF ANALYSIS.

Many chemical methods for the analysis of insecticides have been developed, and a large amount of cooperative work for the Association of Official Agricultural Chemists has been conducted.

Much work has been done by the microscopist in connection with microscopic methods for the examination of insecticides, some of which are mentioned elsewhere in this report. Histological work on sandalwood and Derris is in progress.

PUBLICATIONS.

Thirty-five scientific communications have been made by the laboratory since 1913, and nine others are now ready for publication, the titles of those prepared during this year being as follows: "Arsenic, Copper, and Lead Remaining on Sprayed Fruits and Vegetables," "Arsenates of Calcium II," "Arsenates of Calcium III," "The Deterioration of Calcium Arsenate in Storage," "The Absorption of Copper from Soil by Potato Plants," "Chemical, Physical, and Insecticidal Studies of Arsenicals," "Domestic and Imported Veratrum (Hellebore)," "The Application of Optical Methods to the Examination of Insecticides and Fungicides," "Pine-Oil and Pine-Distillation Product Emulsions: Method of Production, Chemical Properties and Disinfectant Action," "Errors Caused by Nitrites and Nitrates in the Distillation Method for the Determination of Arsenic, and a Method for Their Elimination."

THE COLOR INVESTIGATION LABORATORY.

In the work of the color investigation laboratory the emphasis has been placed upon the study of the laws that govern the chemical reactions employed in the dye industry and the determination of the chemical and physical properties of the substances of importance in dye manufacturing. For such studies the factory chemist rarely has leisure or opportunity. Yet such knowledge is the foundation of the industry.

Since its establishment on December 1, 1915, the results of such of its investigations as have been completed have been announced in 50 scientific papers. Twenty public-service patents have been granted to members of its staff. The laboratory during the whole of its

brief existence has been handicapped by a turnover of its scientific personnel of about 200 per cent. The first and second director of the laboratory resigned to accept a more lucrative industrial post. Not the least of the services of the laboratory has been the training of chemists for the dye industry.

Soon after the United States entered the war the color laboratory was practically amalgamated with the Bureau of Aircraft Production. Studies were made of dope for airplanes, specifications for photographic materials were prepared, the testing of deliveries supervised, a method of preparing acetone from the gases of the Burton still was evolved, and studies were made upon smoke screens, camouflage schemes, and methods of signaling. In connection with this military work, photosensitizing dyes the equal of several of the former German dyes were produced and the methods of manufacture made public. Moreover, a new series of these dyes, named the "kryptocyanines," was discovered. They are characterized by having an extremely sharp sensitizing power farther out in the infra-red portion of the spectrum than any dyes previously known. This new series is most valuable in studying the solar spectrum, and has been supplied for this purpose to the Wilson Solar Observatory. Photosensitizing dyes, so far as they are not available through domestic commercial channels, are furnished to the people of the country, especially to physical-research laboratories and to photographic-material manufacturers. It is planned to close this project as soon as present methods of producing the dyes have been improved by the elimination of a large number of bothersome ether extractions which are very difficult to handle on a large scale. For some of the intermediate bases this result has been accomplished very satisfactorily.

Several analytical schemes which promise to be of great value to manufacturers have been evolved. Among them are the method for the rapid analysis of mixtures of chlorinated toluene, the use of benzaldehyde sulphite compound as a standard in the quantitative separation and estimation of benzaldehyde and benzoic acid, and methods of detecting different sulphonic acids of naphthalene possibly formed in sulphonations. The use of optical crystallographic methods has been introduced in the industry. The physical properties, such as melting points, boiling points, vapor pressure, and solubility curves, as well as various optical properties, of a number of important old and new compounds have been investigated.

Processes for sulphonating aromatic hydrocarbons in the vapor phase have also been devised and arrangements made for industrial development. Studies for the utilization of p-cymene, a waste product of the sulphite-paper industry, have been undertaken, and several dyes have been made from it. Methods of producing carvacrol and a synthesis of thymol have been evolved. Finally, a process for the catalytic oxidation of naphthalene to phthalic anhydride has been discovered. During the war this substance sold for as much as \$7 a pound. After the discovery of this process cooperative arrangements were made with several manufacturing concerns of the country for testing it and producing phthalic anhydride on a large scale. They had had great difficulty in producing phthalic anhydride by the methods used in Germany before that time. The new process turned

out to be well adapted for manufacturing purposes, and the cooperating firms have even exported phthalic anhydride. The price at one time was as low as 45 cents a pound on contract.

During the fiscal year 1920-21 the members of the staff of the color laboratory contributed the following scientific publications: "Cellulose Phthalate, Its Preparation and Properties;" "The Absorption Spectra of the Nitric Esters of Glycerol;" "A Synthesis of Thymol from p-Cymene;" "Synthesis of s-Xyldine;" "Alkali Fusions: II. The Fusion of Sodium Benzene Disulphonate with Sodium Hydroxide for the Production of Resorcinol;" "The Use of Catalysts in the Sulphonation of Aromatic Compounds;" "Phthalic Anhydride: IV. The Vapor Pressure of Phthalic Anhydride;" "Naphthalene Sulphonic Acids: I. Some Difficultly Soluble Salts of Certain Naphthalene Sulphonic Acids;" "Naphthalene Sulphonic Acids: II. A Method for the Qualitative Detection of Some of the Naphthalene Sulphonic Acids;" "Naphthalene Sulphonic Acids: III. An Alternative Method for the Qualitative Detection of Naphthalene 2-7 and 1-6 Disulphonic Acids;" "Synthesis of Photosensitizing Dyes: II. Dicyanin;" "Isocyanin Dyes from Lepidine and Its Homologs;" "The Preparation of Lepidine and Related Bases;" "Tetra-methyl Quinolines;" "Kryptocyanines, a New Series of Photosensitizing Dyes;" "The Preparation and Technical Uses of Furfural;" "Phthalic Anhydride Derivatives: A Partial Collection of Names and References;" "Some Synthetic Resins from Furfural;" "A Compilation of American Dye Patents in Abstract Form." Four public service patent applications dealing with the preparation of furfural, of chloroform, and of photosensitizing dyes have been granted.

OFFICE OF DEVELOPMENT WORK.

The purpose of the establishment of the office of development work in 1920 is given on page 2 of this report, and its various activities in the development of the discoveries of the bureau's staff are mentioned wherever such discoveries are described. In addition to such activities, this office exercises general supervision over the bureau's work upon dust explosions and fires in mills, elevators, and thrashing machines, upon the production of gas from straw and other fibrous materials, and upon commercial dehydration.

GRAIN-DUST EXPLOSIONS AND FIRES.

The dust-explosion and fire-prevention project was inaugurated following a disastrous feed-dust explosion in Buffalo in 1913 by the millers of western New York. Since grain-dust explosions are very similar in character and genesis to coal-dust explosions in mines, in 1914 the Bureau of Mines invited the cooperation of the Bureau of Chemistry, which has continued ever since, though, as the work assumed greater importance to such agricultural industries as grain handling, flour and feed milling, and sugar refining, leadership passed gradually and naturally to the Bureau of Chemistry.

Soon after the establishment of this cooperation reports of frequent explosions and fires in thrashing machines in the Pacific Northwest, alleged to be of criminal origin, were received. The losses that year are said to have affected more than 300 machines and to

have amounted to at least \$1,000,000. The bureau's engineers recognized these phenomena as dust explosions in the production of which three factors played an important part: Smuttness of the wheat, causing great dust clouds of spores; dryness of the atmosphere; and static electricity produced by friction in the machines. Methods for grounding the machines were devised and automatic fire extinguishers and fans to remove the dust were installed. These eliminated for all practical purposes the explosion hazard, besides creating better working conditions about the machines and cleaning the grain so as to reduce dockage and transportation charges and increase the price received for the grain. The value of the bureau's recommendations has been recognized by underwriters, in that stationary thrashers in the State of Washington driven by internal-combustion motors and properly equipped with a dust-collecting fan in accordance with Department Circular 98, pay an insurance rate of \$8.50 per \$100, whereas machines not so equipped pay at the rate of \$10.50 to \$11 per \$100.

The pathologists of the Bureau of Plant Industry believe that the use of fans on thrashing machines to remove spores and prevent their dissemination over the countryside promises to be an important factor in the control of the smut diseases of wheat. The Bureau of Chemistry is cooperating on this problem and during the 1921 season the project was extended to flag smut in Madison County, Ill. The Bureau of Markets believes that the fans if generally used will remove dirt and trash from wheat on the farms, which would be more in the public interest than to have it shipped as at present to market, there to be dealt with as dockage. In this project, too, the Bureau of Chemistry is cooperating.

The bureau's dust-explosion work has been an important conservation factor in the grain-handling and flour and feed milling industry. The explosibility of the dusts produced in these and other dusty industries has been demonstrated so conclusively that these industries are now taking precautions that formerly were never thought necessary. Many of the immediate sources of danger in these plants, such as static electricity, unprotected electric lamps, faulty design of buildings and machinery, uncleanliness, "choke-ups" in elevator legs, etc., have been discovered and pointed out to engineers, managers of plants, and underwriters. There has been active cooperation with fire marshals and underwriters. Undoubtedly much property loss has been prevented by the broadcast spreading of this information.

What can be accomplished was amply demonstrated during the war, when the Secretary of Agriculture made available out of the emergency appropriation \$50,000 a year for a campaign to conserve grain and flour by preventing explosions and fires in mills and elevators. At meetings held in various parts of the country mill and elevator owners and employees were shown, by means of moving pictures, lantern slides, and miniature dust explosions, the danger of dust explosions and fires, and were made acquainted with the circumstances under which they occur. Following the meetings the various mills and elevators were inspected and recommendations made to the managers and superintendents with reference to arrangements that appeared dangerous. The men were then asked by means of special cards to pledge themselves to take all possible precautions to prevent

fires and explosions in the plants where they were employed. The signing of the cards was acknowledged by the department. Through posters, circulars, and the like, much publicity was given to the work. During the time this campaign lasted the losses from explosions and fires were about 40 per cent of those occurring in previous years. As no funds were available to proceed with the work after July 1, 1919, and as the United States Grain Corporation desired that it be continued as a form of insurance for its own operations, the force engaged upon this campaign was transferred to the rolls of the Grain Corporation. The work was continued by that corporation, the Bureau of Chemistry collaborating by furnishing general supervision. With the passing of the Grain Corporation on July 1, 1920, the total losses of the corporation from explosions and fires had been trifling. The results of the campaign were published by the Grain Corporation in the form of the proceedings of the New York conference of the men engaged in the work.

For lack of a specific appropriation, the work of the bureau during 1920-21 was limited largely to the preparation of the material accumulated in previous years for publication. Seventeen papers were published in various journals, as well as Department Circular 171, "Unprotected Electric Lamps—A Dust Explosion and Fire Hazard." Flour, starch, grain dust, spice dust, cottonseed meal, aluminum dust, fish meal, hard-rubber dust were among the materials reported as being capable of causing explosions.

In the course of this work it was discovered that a part, perhaps the greater part, of the fires common in cotton gins, especially in nonhumid regions like Texas, are due to static electricity. A scheme for wiring and grounding gins was devised and applied to a few of them. While the number of such gins is too small to justify sweeping conclusions, it is highly probable that such wiring furnishes valuable protection. Funds have never been available to prosecute this work as vigorously and extensively as the extremely serious losses involved would demand.



OF THE
AGRICULTURAL SERVICE
EXPERIMENT STATION FILE
DEC 13, 1921

REPORT OF THE ENTOMOLOGIST.

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY,
Washington, D. C., August 1, 1921.

SIR: I submit herewith a report of the work of the Bureau of Entomology for the fiscal year ended June 30, 1921.

L. O. HOWARD,
Entomologist and Chief of Bureau.

Hon. H. C. WALLACE,
Secretary of Agriculture.

CEREAL AND FORAGE INSECT INVESTIGATIONS.

W. R. Walton has continued in the leadership of the important work of this section.

EUROPEAN CORN BORER.—The changes in the aspect of the corn borer problem during the past year have not been so great as in former years. The larger appropriation which became available June 7, 1920, made it possible to do better and more extensive scouting work, so that the bureau has been able to keep track of the natural spread of the insect. The apparent increase of the infested area may thus, with reasonable certainty, be said to have been comparatively insignificant in United States territory. The total infested area in the United States at present is 4,629 square miles, of which 2,323 occur in eastern Massachusetts, including a slight extension north of the border line, since in October, 1920, the insect was found in the town of Eliot, Me., close to the New Hampshire border and in the extreme southeastern corner of the State. This particular area is small and does not apparently extend beyond 25 square miles.

The most important development of the year was the discovery during August, 1920, of a rather large infested area in southern Ontario bordering the northern shore of Lake Erie. While this is not in the United States, it has a great bearing on our agriculture, since the frontier of infestation in America is carried at least 125 miles farther west. The western edge of this Canadian spread reaches within 30 miles of the southeastern border of Michigan, and thus offers a great menace to the corn-belt States.

As a result of this unexpected emergency, it has been necessary for the bureau to assume a portion of the duties of the port inspection service of the Federal Horticultural Board.

The inspection work which was necessary to allow the movement of plants included in the quarantine of the Federal Horticultural Board has been very heavy, and approximately 500,000 inspection certificates were issued between March 29 and December 1. In this inspection, many hundreds of corn borer larvæ were found in crops

intended for shipment outside the infested area, and such shipments were intercepted. The unrestricted movement in all directions of motor vehicles coming from infested territory and headed frequently for points many hundreds of miles away was a source of great embarrassment to the quarantine officers, since many of these vehicles carried possibly infested garden products. For example, an inspection of such vehicles at a point on the Massachusetts and New Hampshire State line in a single day showed 75 dozen ears of corn and quantities of beans that had been bought in the infested area and much of which contained corn borers. Four thousand five hundred automobiles crossed the line at this point in a day. Additional legislation is necessary to enable the Federal quarantine officers to act drastically in such cases.

The scouting work has been very extensive, and, in the States known to be infested, covered more than 80,000 square miles. Some scouting was carried on also in 25 additional States, particularly in corn-belt States of the Middle West, but with negative results, and no corn borers were found west of Chautauqua County, N. Y. The small infestation in Erie County, Pa., mentioned in my last annual report, was apparently eradicated during the summer of 1919.

A large amount of artificial control work was done in the New England area between the fall of 1920 and the spring of 1921. The most intensely infested areas, including the market-garden regions near Boston, were covered. Special machinery for burning, steaming, crushing, and the chemical destruction of infested plants was largely used. The idea was to reduce the extent of the natural spread of the insect. In the same way 25 square miles around the village of Silver Creek, N. Y., was thoroughly cleaned up. The cornstalks, stubble, and so on were burned. The results of this work have not been encouraging and show that little can be done in this way, except in the case of isolated infestations, where there is a chance of total extermination. There remains, then, in addition to quarantine efforts and all other possible means of restricting the spread, the chance of natural control.

As indicated in my last annual report, an expert agent of the bureau was located in southern France and has now for more than a year succeeded in sending to the United States large quantities of the natural insect enemies of the borer, and about 6,000 adult parasites of two or more species brought over from Europe have been liberated in the cornfields of eastern New England. We expect to import increasing quantities of these parasites during the coming year.

The reduction of 30 per cent in the amount appropriated for this project has rendered it necessary to abandon other control measures in order to provide for the quarantine, scouting, and parasite introduction work.

GRASSHOPPERS.—Owing to the serious outbreaks of grasshoppers in North Dakota and the surrounding States during the past three years many appeals were made to Congress and the department for help, and the sum of \$40,000 was appropriated to be available July 1, 1921. An expert was appointed April 1 to survey the field and to plan for the necessary work when the appropriation should become available. He has been able to furnish valuable advice and assistance

during the most critical weeks of the grasshopper season to the States of Minnesota, North Dakota, Montana, and Wyoming. At the present writing the very serious grasshopper outbreaks which have prevailed in North Dakota for the past three years show very definite signs of abatement.

CRANE-FLIES.—For a long time the grass on cattle ranges in the interior valleys of California has been seriously injured at times by wormlike maggots which are the larvae of certain crane-flies. Study has shown that these maggots come to the surface of the ground during the night in order to feed upon the tender grass, and in consequence of this habit experiments were made with poisoned-bran baits such as are used against grasshoppers and cutworms. The results were surprising, and it was found that at a cost of about 50 cents per acre 70 to 90 per cent of the maggots can be killed. Exact instructions are given in Department Circular No. 172, published in May, 1921.

THE HESSIAN FLY.—The general wave of Hessian fly abundance and injury mentioned in my last annual report has not increased in intensity during the past year. In the winter-wheat belt cooperative control campaigns conducted by the State and Federal authorities have been instrumental in materially reducing the injury caused by this well-known pest. The results obtained in Ohio, Indiana, and Illinois have been especially gratifying, as both the amount and intensity of the infestations of the Hessian fly have been materially reduced during the past 12 months, although the situation is still unsafe. Infestation in the Eastern States has also declined.

THE CHINCH BUG.—Damage from chinch bugs has continued to be serious in Missouri, Illinois, Indiana, and parts of Ohio. Agents of the bureau have been active in cooperating with State officials in order to reduce to a minimum the damage caused by this insect. A new farmers' bulletin containing entirely original and important information on the use of contact insecticides as a means of destroying chinch bugs is in press.

THE ALFALFA WEEVIL.—The alfalfa weevil has now reached the Nevada-California border and has recently been intercepted by California inspectors in the baggage of tourists who had been camping in Washoe County, Nev. It is probably present in all of the alfalfa-growing regions of Idaho, and may possibly have entered eastern Oregon. It also occurs in the western third of Colorado. Although a very effective means of spraying for the control of this insect has been developed, as mentioned in my last annual report, it has been decided to supplement this by a further effort to introduce into this country other European natural enemies of this pest. One species which was introduced before the war has become established, and is doing effective work in certain localities, but we know that there are other species that occur in the natural home of the weevil, namely, southern Europe, and an expert assistant has been sent to southern France to make further studies and further efforts to send over additional species of parasites.

THE SO-CALLED GREEN-BUG.—For the first time in several years the present spring was marked by a green-bug scare. The abnormally mild temperature of the past winter favored the great multiplication of this insect, and during the late winter it was present in great

numbers in northern Texas. Grayson, Denton, and Collin Counties were especially involved, but 10 or more of the northern tier of counties were included in the outbreak. As the season advanced the insect appeared in smaller numbers in Oklahoma, Kansas, and Missouri. Had the weather continued cool and wet the outbreak might have become disastrous, but during March and early April dry, warmer weather came and the parasites of the green-bug increased until by the middle of April they were in full control; so that, although the oats crop of northern Texas was seriously injured, the damage to winter wheat was comparatively slight.

A careful study of this outbreak was carried on cooperatively between the bureau and the officials of the States concerned, and it was shown that these outbreaks start in fields where volunteer oats have been allowed to stand over from the previous year, and there is little or no evidence to show that the outbreaks in Kansas, Missouri, and Oklahoma were the results of migrations of the insect from Texas. It seems that, if permanent control of the green-bug in northern Texas is to be brought about, it will be necessary for farmers in that region to abandon the practice of allowing and encouraging the growth of volunteer oats and wheat, since these provide continuous breeding places and shelter for the green-bug during the latter half of the summer and fall. Therefore an educational campaign by county agents and extension organizations should at once be begun to induce the farmers of those regions to destroy volunteer grain.

OTHER INVESTIGATIONS.—An investigation of the insects affecting sunflower plants has been started, since this plant is becoming adopted as a silage crop in certain portions of the West where corn can not be successfully grown.

The wheat midge, an insect which has done little or no damage in this country for the past 50 years, has been progressively injurious during the past 2 years in eastern Washington and Oregon as well as in the northern tier of mid-Western States, and an investigation has been begun.

With the introduction of the hairy vetch as a forage and seed crop in the Carolinas, the corn earworm, or cotton bollworm, or tomato fruitworm, as it is called when it affects these different crops, has taken to the vetch with avidity. An investigation of its habits in this connection has been made, and a Farmers' Bulletin (No. 1206) concerning methods of control has been published.

STORED-PRODUCT INSECT INVESTIGATIONS.

This important work has been continued under the direction of Dr. E. A. Back.

INSECTS ATTACKING CORN AND GRAIN PRODUCTS.—The research laboratory at Orlando, Fla., has been investigating especially the corn weevil under semitropical conditions. These investigations have been highly successful in procuring data for the most part entirely new to science.

The laboratory originally established at Athens, Ga., and which was moved to Thomasville, Ga., has been working in cooperation with the Georgia Agricultural Experiment Station and has aroused the interest of a number of prominent farmers and agricultural organi-

zations in the subject of the totally unnecessary destruction of corn by weevils on southern farms. State officials have estimated that this loss averages fully 10 per cent in the South. Corn weevils can be successfully controlled by the intelligent application of the recommendations of the bureau. The beneficial results are immediate and perfectly plain, and have already paid many times the cost of the research work connected with the problem.

BEAN AND PEA WEEVILS.—Investigations of losses to beans and peas grown in California and elsewhere have been continued at the laboratory at Alhambra, Calif. In addition to life-history studies, the problem of control by cold storage and by fumigation has been studied. Important facts have been ascertained. The work continues to receive the hearty cooperation of bean growers and warehousemen on the Pacific coast, and the information which has been secured out there has been applied successfully in the protection of beans, peas, and cowpeas in other parts of the country.

PEANUT INSECTS.—Market conditions during the past year have been such that large stocks of peanuts have remained unsold, and many requests have been received for methods of protecting them from insect attack; and insects have been unusually abundant. Experiments have been made which show that peanuts in the shuck can be held indefinitely if properly fumigated.

INSECTS AFFECTING HIDES.—At the request of certain leather manufacturers, an investigation of this problem was begun during the year. It is estimated that the hide beetle damages baled skins and hides in warehouses to such an extent that \$1,000,000 are lost each year. This loss can be largely prevented by fumigation if the hides are held in storage, and the process recommended does not injure even the most delicate skins.

INSECTS AFFECTING MEAT.—Experts of the Bureau of Animal Industry state that meats worth over \$1,000,000 are condemned annually by its inspectors as a result of insect infestation. Of these insects, the so-called ham skipper, the larva of a small fly, is probably the most serious. An investigation of the insects of this class was begun during the year, important life-history data have been secured, and experimental control work has been started.

INSECTS AFFECTING STORED WOOL.—Owing to economic conditions, large stocks of raw wool have been held in warehouses during the past year, and insects attacking raw wool, feathers, and bristles, and articles manufactured from these stocks, have had an unusual opportunity for development and spread. The ordinary clothes moths have been very destructive to certain supplies of baled wool. An investigation of the biology of the southern clothes moth has resulted in information of much value, not only to owners of raw wool, but to the manufacturers of brushes, upholstered furniture, clothing, weather stripping, etc. In a single case clothes moths injured a consignment of weather stripping to the extent of \$2,000. Such losses as this need not occur if methods recommended by the bureau are followed.

THE CEDAR CHEST AS A PROTECTION AGAINST CLOTHES MOTHS.—Cedar chests have long been popular on account of the supposed protection which they give to clothing stored in them. Their efficacy has been denied, and the truth of the matter has not hitherto been scientifically investigated. In cooperation with the drug, poisonous, and oil plant

investigations of the Bureau of Plant Industry an investigation of this question has been conducted, and the work has been followed closely by the National Cedar Chest Manufacturers' Association. It has been shown that cedar chests made of fresh red cedar can be depended upon to protect clothing provided the clothing has been properly prepared for storage. While the chests do not appear to affect adult moths or their eggs, the young larvæ hatching in the chests or accidentally introduced in the clothing are killed before they do damage. Old larvæ are not killed. The mortality among half to full grown larvæ is considerable, but many of the latter mature and transform.

INSPECTION AND INTELLIGENCE SERVICE.—The cooperation with the Army and Navy for the purpose of inspecting stored food supplies, not only at the time of purchase, but from time to time during storage, and the giving of the necessary expert advice following such inspection, has been continued in the way indicated in my last year's report.

DECIDUOUS-FRUIT INSECT INVESTIGATIONS.

Dr. A. L. Quaintance has continued in charge of this important branch of the bureau work, and since the first of the year has also been charged with investigations of insects affecting tropical and subtropical fruits in cooperation in certain respects with the Federal Horticultural Board.

THE JAPANESE BEETLE.—In the last annual report the territory occupied by this imported pest was estimated to be approximately 50 square miles in the vicinity of Riverton, N. J. Since that time the area has been carefully scouted, and the beetle is now known to occupy 80 square miles in New Jersey and 10 square miles in adjoining regions in Pennsylvania. The quarantine operations, both by the Federal Government and the State of New Jersey, were continued and enforced during the summer and fall of 1920. In the spring of 1921 the quarantine was materially enlarged and was supplemented by a Pennsylvania quarantine. On account of the further spread of the insect five stations in the area were established for inspection purposes. It has been necessary to certify practically all farm products, but actual inspection has been necessary practically only with sweet corn. Sixty-two thousand baskets of corn were examined in 1920 and 846 beetles were found.

Control.—There has been a great deal of experimentation with poisons, but complete success has not been reached. In fact, no effective means of destroying the beetles has been found, although substances have been ascertained which will protect the foliage from their attack. A great deal of experimentation has been made in the search for chemicals which will kill the grubs in the ground, but nothing effective which is cheap enough has been found. Experiments are now being made in the disinfection of soil around the roots of certain classes of nursery stock in order that nurserymen may be able to move such plants from the infested areas. The barrier band described in my last report was discontinued at the close of 1920, since it did not appear sufficiently effective in preventing the spread of the beetles to justify the expense.

These difficulties have shown the need of a very detailed knowledge of the biology of the insect, and this work has been materially

strengthened in the hope that some peculiarity in the mode of life of the species will be discovered which will indicate some possible way of destroying it or reducing its numbers. Careful studies are being made of the types of vegetation, exposures, etc., that the beetles prefer, and also the exposures and types of soil preferred by the grubs. Based on this information, a study is being made of the value of agricultural methods in destroying the grubs in the soil.

Natural enemies.—In the fall of 1920 an additional investigator was sent to Japan to assist in the search for natural enemies and in sending them to New Jersey. The two agents in that country now, with the expert assistance of Japanese entomologists, have made a careful study of the distribution of the beetle over there, and several sendings of predatory and parasitic insects have been made and are now being given attention at the Riverton laboratory.

The native enemies of white grubs in other parts of this country have also been studied, and certain wasplike parasites have been shipped from the Middle West to New Jersey.

PEACH INSECTS.—For the past two or three years Georgia peach growers have experienced heavy losses from the plum curculio, and, on account of extensive appeals, a laboratory for the further study of this insect was established at Fort Valley, Ga., in the late fall of 1920. The Georgia State Board of Entomology is cooperating in this work, and the Bureau of Plant Industry is at the same time working on the fungous diseases of the peach. A mass meeting of Georgia peach growers was held at Fort Valley in December and a campaign was outlined. During the winter months all woodlands, waste lands, and fence rows adjoining peach orchards were cleaned up in the effort to destroy the hibernating beetles. The railroads cooperated by cleaning up waste growth along their rights of way. In the spring, spraying and dusting were begun, and through their committees orchardists were notified during the season of exact dates when applications should be made, with the result that through the entire belt effective work was done and an excellent crop of peaches was marketed with comparatively little curculio damage.

Work against the peach borer, especially with reference to paradi-chlorobenzene, has been continued. This treatment continues to be effective and safe when used according to directions and has come into large commercial use. There is still some experimental work to be done in order to settle certain practical points, such as safety to young trees, effect of soil temperatures, relation of moisture conditions of the soil, etc.

APPLE INSECTS.—Studies of the codling moth have been continued in the Yakima Valley, Wash., the Rogue River Valley, Oreg., the Ozark region of Arkansas, and in northern Georgia. Extensive experiments with sprays and dusts are in progress, and the comparative values of the methods of control by spray guns and by spray rods are being investigated, as well as the different types of power machinery and the value of adhesives in spray solutions. Shipments of parasitized codling-moth larvæ have been sent from the East to the State of Washington.

Certain city boards of health in California have been complaining for the past few years of the amount of spray residue found on pears sent to market, and on apples as well. Consequently a coopera-

tive investigation was begun with the State Department of Agriculture of California the past spring looking toward an improved method of controlling the codling moth on pears which will not leave the objectionable spray residue. The indications are that this work will be successful. The same work was extended to include apples and pears at the Oregon and Washington stations.

An investigation of apple leafhoppers has been begun, with headquarters at Bentonville, Ark. At this station the apple leaf-skeletonizer and the apple leaf-crumper are being studied, since these insects are of considerable economic importance in that part of the country.

At the station at Wallingford, Conn., which is conducted in co-operation with the State agricultural experiment station, studies of the apple maggot have been continued, and experiments in several orchards with arsenate of lead indicate that this treatment has some value. At this station tests of contact dusts in the control of certain apple insects were made in 1920, which have been described in a publication by the Connecticut station.

NUT INSECTS.—The bureau has a station for the study of insects attacking northern nut crops at French Creek, Va., and one at Brownwood, Tex., where insects attacking the pecan are being investigated. At the northern station the walnut husk-maggot has been especially studied. This insect, in localities where the native black walnut abounds, is a serious pest of Persian and other introduced walnuts, promising crops of Persian walnuts having been entirely ruined by it. A preliminary paper has been published which deals with methods of control. At this station studies have also been made of snout-beetles which attack the young fruits of black walnut, the fruits and shoots of butternut, Japanese walnut, and other introduced walnuts of the butternut type, and others which attack hickory nuts and the shoots of hickory. The insects which cause wormy chestnuts are also being studied.

At the Texas station the worst pecan enemy is the case-bearer. Its life history has been carefully studied, and numerous experiments with arsenical dusts and sprays appear to show that the insect may be materially reduced in numbers where such treatments are practicable. In some sections the so-called obscure scale is a serious pest of the pecan, and the bureau's work shows that it can be controlled by spraying either with the commercial lime-sulphur solution or by oil emulsions during the dormant season. No good method of control has been found for the pecan weevil, although there still remain some hopeful lines of experimentation. The publication of a monographic report on the pecan insects of the Southwest is contemplated.

GRAPE INSECTS.—The work at the Sandusky, Ohio, laboratory has been continued in cooperation with the State agricultural experiment station. A marked improvement in the grape-growing industry has followed the general adoption by the growers of the spray formulas developed by the bureau. A high percentage of sound fruit has been obtained by following the two-spray schedule for the control of the berry moth. It has been found, however, that certain varieties of grape are subject to spray injury, and modifications of the mixtures are still to be worked out in such cases. It is believed that a single spraying, thoroughly done, will control the berry moth in vineyards which are not too seriously infested.

In the course of this work it has been shown that calcium arsenate, which is cheaper than arsenate of lead, can be successfully used in the control of the grape-berry moth on Concord grapes, but that it burns the leaves of Ives' Seedling and certain other varieties. Magnesium arsenate is more injurious than arsenate of lead, and can not be used. Fish-oil soap, casein, and other materials have been found to be valuable as adhesives and spreaders.

The grape leafhopper is just now causing premature falling of the foliage in northern Ohio, and poorly colored and poorly ripened grapes result, causing a depreciation last year in some cases of \$75 to \$100 per ton. Careful studies of this insect are now being made.

At Fresno, Calif., the bureau is experimenting with remedial operations on a commercial scale against the grape mealybug. This insect winters partly in the egg stage, which makes it very difficult to handle. Further tests with sulphur fumes, at one time recommended, have been abandoned, since it has been shown that they injure the plants and are not effective. Experiments are now going on with miscible oils, but conclusions have not been reached.

The large larva of the Achemon sphinx moth occurred again in alarming numbers in Merced County in July, 1921, stripping 100 acres of vineyards and causing the loss of 200 tons of grapes. This insect may be controlled by the use of arsenate of lead and sulphur dust, or with 5 pounds of the arsenate of lead to 200 gallons of spray, some glue being added to the spray to make it adhere.

INSECTICIDE INVESTIGATIONS.—Insecticides are so largely used in orchard work that Dr. Quaintance is naturally the representative of this bureau on the Federal Insecticide Board and handles in a general way the insecticide questions for the bureau. Year after year investigations of miscellaneous insecticides are continued under his direction. A comparative study of arsenicals as insecticides, in co-operation with the Bureau of Chemistry, was practically concluded at the close of the year, and a manuscript has been prepared for publication. It includes a study of raw materials, methods of manufacture, analyses, and classification of arsenicals, compatibility of insecticides and fungicides, relative toxicity of arsenicals, and so on. Many interesting results have been reached, most of which will be of practical application.

A study has been made of the insecticidal constituents of plants, and 180 different preparations have been made from 46 different kinds of plants, excluding tobacco, quassia, and derris, the properties of these being generally acknowledged. Of the 180 preparations, only a few are worth further study. The possible development of contact insecticides as a substitute for nicotine or tobacco extract has been investigated. It has been found that the most highly poisonous compounds are among the organic nitrogen compounds. Some of these, like pyridine, have but little toxic value, while others, like piperidine sulphate and trimethylamine hydrochloride are decidedly toxic at less than 1 per cent concentration. A pyridine derivative, however, has been developed which promises success against soft-bodied insects. It has also been found that heavy petroleum-oil emulsions in a dilute condition will be useful against plant lice under certain conditions.

VEGETABLE AND TRUCK-CROP INSECT INVESTIGATIONS.

The work on this series of projects has been continued under the direction of Dr. F. H. Chittenden. The importance of this work has been greatly increased by the sudden appearance and rapid spread of the Mexican bean beetle in Alabama and adjoining States.

SWEET-POTATO WEEVIL ERADICATION AND CONTROL.—Work on the sweet-potato weevil in Florida and Georgia has continued. Inspection of the infested district in Baker County, Fla., shows a great reduction in the number of farms infested, these being in sections where it is difficult to secure cooperation from growers. In Charlton County, Ga., infested farms have been reduced to such an extent that only two are now known to be infested. Contracts have been signed with about 200 farmers for the delivery of weevil-free draws and seed sweet potatoes for the following spring. Hundreds of thousands of draws have been distributed in infested regions in co-operation with the Florida State Plant Board, as also many bushels of seed potatoes and vine cuttings. Experimental life-history work, including fumigation and the control of the weevil in seaside morning-glory vines, has been continued. Progress has been made in its control even in the presence of wild host plants. As a result of the work, it will be possible to declare two-thirds of the previously infested area weevil-free and all but a few of the infested farms in this area will probably be cleaned up during the year. Research work in south Texas has been completed and results are ready to publish. It has been demonstrated that adults can be starved out in between 9 and 37 days. In Alabama no new infestations have been found and that State, as well as Georgia, is considered practically weevil-free.

PREVENTING THE SPREAD OF THE MEXICAN BEAN BEETLE.—The Mexican bean beetle, an insect which has been known as a pest in New Mexico and neighboring States for about 50 years, was discovered in the vicinity of Birmingham, Ala., during the fall of 1920, where it has been accidentally introduced in alfalfa hay from Colorado. Preliminary scouting was carried out by the Alabama State Experiment Station, with which institution the bureau is now cooperating, to learn the general limit of infestation, but because of the lateness of the season and lack of funds this inspection could not outline the entire infested area, although the insect was found in about 13 counties in Alabama over an area of about 3,500 square miles.

When the Federal bill appropriating \$100,000, of which \$25,000 was immediately available, was passed March 3, 1921, the field work was organized in two main divisions—research and regulatory scouting. The research work consists of life-history and food-plant studies and tests of control measures. Up to the present distinct progress has been made along all research lines and a large series of dusts and sprays has been tested out on several complete experiments. While the insect made its appearance in the vicinity of Birmingham in March, it was much later in appearing around the outer edges of the known infested zone. In following up this work the insect was soon found in northeast Georgia in several counties, and from there was traced to the vicinity of Chattanooga, Tenn. These observations made it apparent either that the insect had been present for a much longer period than had been believed or that it spread more

rapidly than had been expected. It was then learned that about 10,000 square miles were quite generally infested with the bean beetle in 3 States—Alabama, Georgia, and Tennessee—and that infestation beyond this point, while scattered, is well established. Considering all reports of inspection up to July 19, 1921, the beetle has been found present in 30 counties in Alabama, covering an area of about 18,500 square miles; in Georgia the infestation covers 26 counties, with a total area of about 6,000 square miles; in Tennessee it covers 25 counties with a total area of about 8,000 square miles. In addition, the insect has been located in Whitley County in Kentucky and in Oconee County in South Carolina. With the exception of one locality the infested area apparently surrounds a central area of heavy infestation, the single exception being Thomasville, Ga. At the present time 83 counties in 5 States are known to be infested with the Mexican bean beetle, the area covering approximately 34,000 square miles. It is probable that the insect has spread largely by flight, since it is an unusually strong flier, and that it has also been spread to a lesser extent by commercial shipments of infested food plants and other crops and in hay along railways and the larger roads. The large shipping centers of Birmingham and Chattanooga are well within the infested territory, and the insect has been found within 17 miles of Atlanta, 16 miles of Knoxville, 36 miles of Montgomery, and 44 miles of Nashville. The infested territory reaches within 16 miles of Mississippi, 3 miles of North Carolina, 23 miles of Virginia, and 10 miles of Florida. While it is difficult to predict the future spread of this insect, it has very evidently gone beyond the bounds of control by human agencies, and the present infestation will probably spread rapidly within the next three years, and in time it may menace the principal bean-growing sections of the entire country east of the Mississippi River.

Since, then, the insect is apparently not amenable to control by quarantine, the most promising line for future work naturally follows research and extension. At the very outset it was discovered that the insect had not only acquired new food plants, especially cowpeas, but that it had acquired an entirely different life history in the warmer and longer season of Alabama and neighboring States, for whereas in Colorado in normal years the species produced only one and a partial second generation, in its eastern occurrence it will evidently produce four or five generations annually. Investigations are now being carried out to determine all possible food plants, including wild ones, which were never attacked in its western range and to secure, if possible, a resistant or semiresistant variety of beans, cowpeas, and other seeds which may be introduced from Mexico or elsewhere in the infested region. An expedition has been sent to Mexico and Central America to search for natural enemies, since tropical America is known to be the home of several related species of beetles with similar habits, none of which are known to be pests in those countries. Efforts will be made to introduce all possible natural enemies as well as to learn the habits of natural enemies in the known range of the Mexican bean beetle in this country. Similarly any resistant or semiresistant varieties of beans which may be found in Mexico will be introduced and thoroughly tested by every possible means. Large-scale work is also being conducted

to determine direct control measures which will make the growing of beans profitable and practical in the presence of the insect. The research work is still in its infancy, and to be effective should be carried on upon a larger scale wherever the insect is known to occur in the United States.

INSECTS INJURIOUS TO POTATO, TOMATO, AND RELATED CROPS.—Work on the Colorado potato beetle has been continued. Life-history work on this species has never been conducted in the South until the present year, when five generations were reared in Louisiana. Undiluted lead arsenate in different proportions combined with air-slaked lime was tested and gave very satisfactory results. The potato leafhopper, a small insect which is the cause of "hopperburn" or "leaf-burn" on potatoes in the potato-growing sections of the Northern States, has been very carefully studied in Wisconsin, and Farmers' Bulletin No. 1225, covering this subject, is in the printer's hands. A more detailed account has been prepared in cooperation with the Wisconsin State Experiment Station. It is a serious enemy of the potato as well as of the bean and sugar-beet crops in the Northern States, and the condition termed "hopperburn" may bring about the ruin of an entire crop in a very short period. It may be held in check by spraying with Bordeaux mixture. The tarnished plant-bug has been investigated from the standpoint of its occurrence in and near the District of Columbia, and its wild and other food plants on which the insect breeds have been thoroughly investigated. The control of the tomato fruitworm has been continued in Louisiana, where powdered calcium arsenate gave good results, as did also the planting of sweet corn as a trap for the worms to lure them from the tomato crop. The potato flea-beetle has been under continual observation, but of the various substances tested during the year none has proved better than Bordeaux mixture, a deterrent, and still the standard method for its control. Efforts are being made to introduce into France, Morocco, and western Australia one of the valuable parasites of the potato tuber moth which help to hold this pest in check in California.

INSECTS INJURIOUS TO BEANS AND PEAS.—As a result of the accidental introduction of the Mexican bean beetle into the Gulf States and the probability of its continued and rapid spread, additional work is demanded in the infested area, as also elsewhere; and because of the necessity of increasing the crops in regions which are bean-beetle free, it will be necessary to control all other important pests on beans and related crops. Thus the bean fly, or seed-corn maggot, which has been unprecedently injurious during the past spring almost throughout the Atlantic region, has been given additional study and its life history has been worked out. Sodium arsenate incorporated in a bran mash has proved highly effective, being both economical and rapid of action. We hope to try this on a large scale next spring and to test it against related root maggots. The bean leaf-beetle, which has been destructive in the Southern States, has also been studied. The pea aphis and the bean aphis have been very carefully studied on the Pacific coast, and a report on their life history and control has been prepared. Nicotine sulphate in a dust carrier has been found very effective as a remedy. The pea moth has been given additional study, and the work will be continued. The lima-bean symphylids

require study in the States of California and Idaho, where they are doing great damage to lima beans and some other crops.

INSECTS DESTRUCTIVE TO CABBAGE AND OTHER COLE CROPS.—The imported cabbage webworm has been studied in Louisiana, and both arsenate of lead and paris green, with laundry soap added as a spreader or sticker, have been found effective, while calcium arsenate and zinc arsenite sprays were ineffective. A preliminary account of the European horse-radish webworm, which recently made its appearance in injurious numbers in Virginia, has been completed, and the results are available for publication as Department Bulletin 966. A species of flea-beetle, previously unknown as a pest, has attracted attention in Monroe County, N. Y., and it would appear that infestation, which is principally to seedling radish, as also to turnip, cabbage, and related crops, is somewhat extensive. The brassy cabbage flea-beetle, a related species and also a new crop enemy, especially to turnip and mustard, has been carefully studied in Louisiana. It has been found to be extremely prolific, a single female depositing upward of 1,400 eggs, while 8 generations have been reared in less than a year. While not as yet a pest of great importance, it is likely to develop into one in the absence of its wild food plants.

CUCURBIT INSECTS.—Experimental work on the control of the striped cucumber beetle, which is not only directly injurious to all cucurbits but is the principal carrier of cucurbit diseases, has been continued, and tests have been made of new and promising insecticides and deterrents. Valuable data on the insect's behavior, including the discovery of two new early food plants, have been obtained. Of the various direct remedies tested, nicotine sulphate in dust form has proved the most promising in the vicinity of the District of Columbia, especially where applied by means of a knapsack bellows, when it proved to have between 90 and 100 per cent killing power. It forms a good covering over the plant and penetrates the earth around the base of the plant, driving the insects up from concealment and killing them. It also acts strongly as a deterrent. Plants thus treated produce full yields of fruit in spite of heavy infestation of the plants when very young. Another season's work will be necessary to determine if this effectiveness will hold for other regions.

SUGAR-BEET INSECTS.—Work on the sugar-beet leafhopper, the cause of "curly top" so injurious to the sugar-beet industry, has been continued in cooperation with the Bureau of Plant Industry. The principal investigation, in line with the most productive results already achieved, lies in the selection of resistant beets, of which last season more than 350 types were selected. These are being brought through to seed, after an all-winter's silage, in order to determine the percentage of resistant beets in each case, all selected separately receiving inoculation. The results to date are very promising. Department Bulletin No. 967 on the blister beetles affecting sugar beets and truck crops will soon be available, and two publications, including Farmers' Bulletin 1193, have been issued on the beet leaf-beetle dealing with appropriate control measures.

STRAWBERRY, BLACKBERRY, AND RASPBERRY INSECTS.—The strawberry weevil and strawberry leaf-roller, the two most important insect enemies of these crops, have been the subject of continued experiment in New Jersey during the year, and work on both forms is

nearly complete. A large series of insecticidal experiments against the former prove that dusting with sulphur 1 part and lead arsenate 5 parts, as developed at the New Jersey State station, is the best method of control. It acts first as a repellent and afterwards as a poison. Against the strawberry leaf-roller arsenate of lead, 3 pounds to 50 gallons of water, applied when the larvæ are just hatching from the egg, has proved the best remedy. In New Jersey it has been learned that 75 per cent of this pest is destroyed annually by a parasite new to science. Efforts will be made to introduce this natural enemy in other regions infested by the leaf-roller. Work has been continued on the borers which affect the canes of blackberry and raspberry.

EXPERIMENTS WITH NICOTINE SULPHATE IN CALIFORNIA.—Experiments with nicotine sulphate in a dust carrier have been conducted against truck-crop insects in California. Flowers of sulphur and lime are proved to absorb less nicotine than does kaolin, and hence are more satisfactory as carriers. Lime, however, tends to break up the nicotine sulphate and form calcium sulphate and free nicotine, resulting in such volatility that the mixture deteriorates very rapidly unless in hermetically sealed containers. This increases the commercial cost but results in increased effectiveness. A preliminary report of this work has been published as Department Circular 154.

A 2 per cent nicotine mixture by weight was found satisfactory for the control of the melon aphis. With hand dusters about 2 acres per diem per man can be covered, using from 30 to 50 pounds of dust. With a light power outfit, using two hoses and operated by a team and two men, 3 to 4 acres an hour can be covered, using 50 pounds dust to the acre. The cost of material ranges from \$4.50 to \$7.50 per acre.

For the pea aphis a dust containing at least 2.4 per cent of nicotine was required for a satisfactory kill. Many growers prefer to use a mixture containing 4 per cent nicotine (10 per cent of 40 per cent nicotine sulphate) which is very active. The cost of this is, however, prohibitive except with the most profitable crops, and spraying is accordingly advised in cannery and market fields. With one pint of 40 per cent nicotine sulphate to 100 gallons of water, a properly arranged spray boom, and a pressure of 200 pounds, the usual nicotine-soap mixture will secure good results at a cost of \$3 per acre.

WORK ON THE GIPSY MOTH AND THE BROWN-TAIL MOTH.

Work on this project has been continued under the supervision of Mr. A. F. Burgess, with headquarters at Melrose Highlands, Mass. During the past year the work has been carried on in the face of unusual difficulties. The most careful estimate that could be made showed that \$400,000 would be necessary for the thorough scouting and treatment of the border area in New England, to enforce the quarantine, and to conduct the experimental work on which all sound methods of field operation must be based.

The area that it was necessary to scout and clean in order to prevent the spread of the insect to the west comprised two or more tiers of towns from the Maine-New Hampshire line and north of

Conway, N. H., extending to the Connecticut River, thence west of the river in Vermont and to the Massachusetts line, and southeasterly across Massachusetts and Connecticut to Long Island Sound.

To carry on this work an appropriation of only \$250,000 was made available for the fiscal year. And then, about the 1st of July, came staggering news. The gipsy moth was found near Prospect Park in Brooklyn. A few days later it was found on a large estate in Somerville, N. J., and the fact was soon established that at the latter place a large block of Koster spruce imported from Holland 10 years ago had brought over at that time (before the passage of the Federal horticultural law) egg masses of the gipsy moth, and that the moth had been multiplying there unnoticed during all these years. But this was not the worst, although several acres of these trees were found to be completely stripped: Trees from this estate, and in some cases from the infested spruce planting, had been sold nearly every year since the original trees were received from Holland. Fortunately, an accurate record of the shipping lists had been made, and these were secured so that the shipments could be traced. Two hundred and sixty-one shipments had been sent to 17 States outside of New Jersey, as follows: Connecticut, Delaware, District of Columbia, Florida, Illinois, Indiana, Kentucky, Maryland, Minnesota, Missouri, New York, North Carolina, Ohio, Pennsylvania, Virginia, and Wisconsin. In addition to these, 318 shipments had been sent out and planted in 72 different towns in New Jersey. And this was not all: Some of these trees had been bought by nurserymen and landscape architects, and had been reshipped to other points. This meant an enormous labor, but it is believed that all the stock that was sent out has been traced and the territory inspected, with the result that small infestations were found at Loretto, Pa.; Garrison, Roslyn, and Kew Garden, N. Y.; Deal Beach, Wykoff, South Orange, Scotch Plains, Paterson, Madison, Glenrock, and Elizabeth, N. J., and another infestation was found at Mendham, N. J., although this one might not have come from the Somerville colony.

Immediate steps were taken with the New York authorities and the Brooklyn Park Department to stamp out the Prospect Park outbreak, and the eradication of this colony is expected at an early date. When the Somerville, N. J., colony was found no State funds were available. Immediate arrangements were made to prevent entrance to the property, and the territory about was carefully scouted by selected scouts transferred from New England. They found about 100 square miles of infested territory. State quarantines were established and suspected products shipped from infested areas were inspected by employees of the bureau. Congress was asked for a deficiency appropriation of \$300,000, and by December 1, 1920, nearly all the bureau funds for field work had been exhausted. At a special session of the New Jersey Legislature in November \$112,000 was appropriated, and a large number of the New England field force were taken on the State pay roll, the work in New Jersey, however, being managed by the bureau in cooperation with the State. Early in March all of these State funds, together with \$25,000 furnished by the owner of the originally infested estate at Somerville, had been spent for labor or allotted for the supplies and spraying equipment for use late in the spring.

On March 3, 1921, a deficiency appropriation of \$225,000 was passed by Congress and approved by the President, and a hurried attempt was made to reorganize the force to carry on the spring and summer work in New Jersey, New York, and New England and to complete the scouting in New England that should have been done last winter.

It appears now that the infestations in New York are all of moderate size. They have been thoroughly treated in cooperation with the State authorities, \$25,000 having been appropriated by the State for this purpose. The Pennsylvania infestation is confined to a single estate, and work there and in a surrounding area has been done by the bureau cooperatively with the State officials.

In New Jersey the scouting operations carried on during the winter showed the insect present over an area of 417 square miles. In most of this territory the infestation is very slight, the worst section being in Somerville and south and east of this town. The egg clusters were thoroughly treated over the entire area during the winter, over 3,000,000 clusters being found in the spruce block where the infestation started. All badly infested spots, together with the entire infested estate, were thoroughly sprayed, some of the worst points being treated twice during the season. The result has been very satisfactory, but it is obvious that complete extermination of the insect in New Jersey can not be accomplished under four years of additional continuous and thorough work.

The infestations in New York and Pennsylvania are much smaller, and the insect should be eliminated in a shorter time.

The New England area has suffered severely during the past year because of our inability to do the necessary work at the proper time, on account of lack of funds. The border scouting had to be discontinued December 1 and could not be resumed until March 15. During the border scouting 65 towns were found to be infested—4 in New Hampshire, 31 in Vermont, 22 in Massachusetts, and 6 in Connecticut—and all of these were quarantined July 1. Very possibly other towns are infested that could not be reached during the past winter.

The progress of the imported natural enemies has been slow, and it varies from year to year. Some are affected adversely by severe winter weather, and, as most of the species are able to migrate considerable distances, their presence in a given area one year does not always give positive assurance that they will be found there in increasing numbers the following season. Some of the imported parasites have been unnoticed for years, and have reappeared. For example, in 1908 several shipments of a large ground beetle known as *Carabus auratus* were imported from France and colonized as a possible ally in controlling the gipsy moth. During the years that followed none were found, and the importation was thought to have been a failure. In the early summer of 1920, however, 12 years after its introduction, several specimens were collected a few miles from the place where it was liberated, and more have been found this year. The value of this predatory species as an enemy of the gipsy moth has not been demonstrated, but it does destroy large numbers of cutworms and soft-bodied insects. Nearly all of the introduced parasites that have become well established occurred rather abundantly last summer. In relatively few cases were they present in

sufficient numbers to bring about effective control, and it seems quite likely that further search for additional natural enemies in Europe and the reintroduction of some of the species that have not been recovered in New England might result in valuable assistance.

The brown-tail moth has been present in relatively small numbers during the past five years, and its natural enemies, and especially the introduced parasites, undoubtedly played an important part in bringing about this condition of affairs. It seems to be increasing of late, and has been more abundant this summer than during the previous year.

During the present summer at certain points in New England tree stripping has been very noticeable. In Massachusetts, east of Worcester, except toward the south, it has been bad. In New Hampshire, south of Lake Winnepesaukee and east of the watershed between the Connecticut and Merrimac Rivers, there was extensive stripping, and the same may be said of the southeastern part of Maine. Conditions on Cape Cod, however, were better than for several years past.

This moth work should be supported financially in a manner that will give adequate protection against the spread of the insects. If allowed to spread the loss will be enormous. Proper sums should be appropriated for the protection of the rest of the country. It will be very economical to do this, and it will be very extravagant in the long run not to do it.

SOUTHERN FIELD-CROP INSECT INVESTIGATIONS.

Investigations of insects affecting southern field crops have been continued under the direction of Dr. W. D. Hunter.

COTTON INSECTS.—Cotton boll weevil investigations have been centered around the newly developed process of controlling the weevil by dusting with dry powdered calcium arsenate. Plat tests have been conducted with the object of improving the poison used as well as improving the methods of application. The large-scale poisoning was still further extended during the season of 1920 to include something like 75,000 acres of treated cotton under the supervision of experts from the Delta laboratory. Practically all of this work was carried to a successful completion in spite of unfavorable conditions, and much information of value in outlining commercial practices was secured. A brief popular summary of rules for poisoning has been issued. This is being used very widely by farmers as a basis for their commercial poisoning.

The study of dusting machinery has been continued; numerous new machines put on the market by various manufacturers have been tested and modifications and improvements suggested. During the past season the Delta laboratory was able to develop the intermediate type of dusting machine which has been so long desired, and this was thoroughly tested. As a result of this work, there was issued a basis design on a one-mule, one-wheel, two-row type of dusting machine. This design was submitted to all interested manufacturers, and several have models on the market based on it. These machines are exceedingly simple and are available at approximately \$100 each, which means that the cost of dusting machinery for poisoning

is reduced practically one-half. Still other types of machines are in course of construction which, when completed, will be adapted to conditions for which we do not now have suitable machines.

The calcium arsenate inspection work has been maintained in co-operation with the Federal Insecticide and Fungicide Board. Something like 2,000 samples of calcium arsenate submitted by farmers were tested and the senders advised relative to its suitability for cotton-dusting purposes. In addition, about 1,500 samples of calcium arsenate collected by the official inspectors of the Federal Insecticide and Fungicide Board were tested for plant injury and weevil toxicity. The information secured from these tests, of course, served as a basis for the decisions of the board with regard to whether such material should be sold.

In connection with the chemical work, the manufacturers have been interested in the problem of standardizing calcium arsenate, and considerable progress has been made with regard to improving the material on the market for cotton dusting. In the past there has been no definite means of measuring the physical quality of calcium arsenate, and this has resulted in much unsatisfactory material being distributed. There has now been designed a standard tester which makes the operation purely mechanical and this has been adopted by the various manufacturers.

At the end of the season of 1920 a survey was made of the results secured by farmers in various portions of the cotton belt, and an attempt made to analyze the reasons for success or failure in poisoning. A number of important points developed in this study, and it was soon found that the rapid use of calcium arsenate had taken the work into territory where the field force was not prepared to issue advice, and an undesirable number of failures were resulting. Consequently the work was completely reorganized in 1921, and 11 new stations opened in sections ranging from South Carolina to south Texas with a view to studying the local conditions for cotton dusting, as well as attempting to advise the farmers in each section as to the best methods to pursue.

TOBACCO INSECTS.—The tobacco hornworm still is the most important tobacco pest in Kentucky and Tennessee. Diversification of crops, the high price of labor, and the passing of the careful and efficient hand wormer keep the machinery and dosage problems in the forefront. During the past summer a somewhat rough working model of a mule duster, especially adapted for use in the tobacco field, was constructed at the Clarksville, Tenn., laboratory and tested on 75 acres of tobacco. This machine applies the dust insecticide to two rows of tobacco at the same time, does the work very thoroughly, and is handled as easily as the ordinary plow. Using this machine, one man and a mule will do more and better work than two men with hand dusters. A demand for it has already been created; consequently every effort will be made toward perfecting the machine during the year.

Plant beds for the setting of about 800 acres of tobacco were dusted with arsenate of lead during the spring just passed to reduce as far as possible the number of hornworms in the area selected for control of hornworms by reduction of the hibernating generation. This experiment will be prosecuted vigorously in the fall and it is ex-

pected that some indication of its probable value will be obtained in 1922.

A very excellent piece of work was done during the spring and early summer at Quincy, Fla., in carrying through two generations of the tobacco flea-beetle in the laboratory. The records checked exactly with the appearance of the first and second generations in the field. A third generation also was bred entire, though not in lineal line with the first two. Climatic conditions helped to control both the tobacco thrips and the tobacco flea-beetle in the Georgia-Florida tobacco belt, so that little advance could be made in perfecting remedies for either pest. However, the dusting and spraying as recommended by the agent in charge served, in conjunction with the peculiar weather conditions, to reduce damage by both insects to a minimum.

The tobacco splitworm, which threatened to wipe out the tobacco industry at Dade City, Fla., a few years ago, this year made its appearance in noticeable numbers first in the Quincy section. This outbreak is being watched and studied very carefully and will be given particular attention in the spring, so that the necessary repressive measures may be adopted in time should the infestation prove to be alarming.

SUGAR-CANE, RICE, AND CACTUS INSECTS.—During the summer of 1920 the work of collecting tachinid parasites of the sugar-cane moth borer in Cuba and forwarding them to Louisiana was continued, a large number of parasites being secured. The work was made possible largely by the contributions of Louisiana sugar planters, nearly \$7,000 having been raised to pay the salaries and expenses of four collectors in Cuba working under the direction of an employee of this bureau. A sufficient number of parasites was obtained to allow of a colony being placed on the plantation of every contributor to the fund.

The parasites were afterwards found to have attacked the larvæ of the moth borer at the Louisiana Sugar Experiment Station, New Orleans, on various Louisiana plantations, and on a plantation near Brownsville, Tex., where some were released. There is some evidence that the parasite passed the winter of 1920-21 successfully, and it is believed that it will be found to be an efficient factor in control.

Good results continue to be obtained with the system which the bureau, in cooperation with the Louisiana Sugar Experiment Station, devised of avoiding the destruction of the native egg parasite of the moth borer by avoiding the burning of cane leaves left on the fields after the cutting of the cane. Instead of being burned, the leaves are partially plowed under, thus causing them to decay and combine with the soil. Not only is the moth borer controlled in some degree, but the soil is left in much better condition than before plowing. The Cuban parasite will assist in the control afforded by the egg parasite.

INSECTS AFFECTING THE HEALTH OF MAN AND DOMESTIC ANIMALS.

CONTROL OF FLIES AND OTHER INSECTS IN ESTABLISHMENTS OPERATING UNDER FEDERAL MEAT INSPECTION.—This project, which is carried out cooperatively with the Meat Inspection Service of the Bureau of

Animal Industry, was given some attention during the year. A Survey was made of the packing houses in the principal centers in the Central States to further study the practical problems involved in fly control under packing-house conditions. It was gratifying to note the very marked improvement which had taken place in regard to fly conditions about these establishments as compared with conditions when the work was begun in 1915. While it will be found necessary to wage a continual fight against flies around packing establishments, many of the problems have been solved by the permanent elimination of the breeding places on the premises through modification in construction, equipment, and methods.

SCREW WORMS.—Much attention has been given to the study of the screw worm, and especial stress has been laid on the control of this destructive live-stock pest under range conditions. In this work close cooperation has been maintained with the experiment station of the Texas Agricultural College, one investigator being located at substation No. 14 of the Texas Experiment Station in the center of the sheep and goat raising region near Sonora, Tex. In the vicinity of that station extensive tests have been carried out with the control of the screw-worm fly by systematic destruction of carcases and trapping and poisoning of adults. Much attention has been given to the question of developing a suitable material for destroying the maggots and repelling the flies from wounds. As a result of this work some promising formulæ have been developed and are being given to the stockmen in the form of a bulletin from the Texas Agricultural Experiment Station.

The Bureau of Chemistry also has cooperated with this bureau in initiating an extensive series of experiments to determine the value of various chemical compounds and mixtures of them as repellents for the screw worm and other flies, as attractants for the flies, and as larvicides. No very definite conclusions have been reached in connection with this work, but it is hoped that certain fundamental principles underlying the chemotropic reaction of flies will be determined.

As a result of our campaign against the screw worm in southwest Texas, numerous stockmen have purchased flytraps of the type advocated and are operating them on their ranches. On this account it seems advisable to get further information on the attractiveness of dried slime and other concentrated dried baits. Some very promising results are being secured along this line and some stockmen report a very material reduction in screw-worm cases since the fly-trapping campaign was begun.

Ox WARBLERS.—Investigational work dealing especially with the seasonal history of the destructive cattle pest known as warbles or "wolves" has been continued. Large-scale experiments to test the toxicity of various chemicals to the warbles have been carried out and a very effective ointment has been hit upon. This consists of a mixture of iodine and vaseline. It has been found that 100 per cent efficiency can be secured against the common species, *Hypoderma lineatum*, by pressing this material into the warble holes in the backs of cattle. While other chemicals have been found to give nearly as high killing power, this mixture has the advantage of simplicity of application and a considerable percentage of the grubs drop out of the backs of the cattle after they have been killed.

POULTRY PARASITES.—A test to determine the effect of lice on fowls, especially as determined by egg production, has been continued throughout the year, and some attention has been given to the control of other destructive parasites such as the feather mite, roost mite, chicken tick, and sticktight flea. This work has been more or less along the line of securing the adoption of satisfactory control measures already worked out and published upon.

INSECTS AFFECTING THE HEALTH OF MAN.—The work of the bureau laboratory at Mound, La., on malaria mosquitoes has been continued. These investigations relate to the American species of *Anopheles* that transmit malaria, the conditions that favor the production of these mosquitoes, the regions where these conditions exist, the requirements for malaria transmission, the development of the malaria parasite in the body of the mosquito, the resulting human infection, and the effect of such infection upon the time and efficiency of those having the disease. Malaria, by reason of the breeding habits of *Anopheles*, is a rural disease. It affects the farming class more than any other class of people with the possible exception of the people engaged in the lumbering industry in the swampy regions. The economic loss runs into hundreds of millions of dollars annually aside from the nondevelopment of great tracts of fertile land where malaria is known to exist. The work is in contact with other agencies interested in the control of malaria in this country, including the International Health Board, the Prudential Insurance Co., Tulane University of New Orleans, the National Malaria Committee, and the United States Public Health Service.

The lines of work have developed from that of a rather general survey to that of intensive investigation. The general line and policy of the work—that is, the relation of malaria to crop production and to agricultural development, the mosquitoes concerned in the transmission of the disease, the sources of these mosquitoes, and the methods of control of these mosquitoes under typical plantation and farming conditions have not been changed, but the lines have been extended and reduced to certain definite projects. The control of malaria rests on the control of the mosquitoes that convey the disease. The methods of control must rest upon the biology of these mosquitoes and the problem, therefore, primarily is an entomological one. The disease being rural, it is likewise an agricultural problem. The work then becomes the foundation of the future progress in the control of this great menace to large areas of fertile land.

TROPICAL AND SUBTROPICAL FRUIT INSECT INVESTIGATIONS.

The immediate direction of the work of this branch was taken over by Dr. A. L. Quaintance in December, 1920, certain features of the work being handled in cooperation with the Federal Horticultural Board.

INSECTS AFFECTING CITRUS FRUITS IN CALIFORNIA.—The citrus red spider is at present one of the most important problems in southern California. During the year experiments were carried on with the comparative efficiency of several sprays, including lime-sulphur and distillate cresylic-acid soap emulsion. The latter was found

to be superior to the lime-sulphur spray. Its efficiency has been demonstrated in several citrus districts and it has been adopted by a large number of growers with great success in the control of the red spider. Careful biological studies of the red spider and mites on citrus trees are being carried on in the interior southern California districts. Further studies have been made with liquid hydrocyanic-acid gas in order to gain more satisfactory results, especially with the larger trees. The fumigation schedule formerly in use has been revised, and the revision has been generally adopted with notably better results.

In order to get definite data on what has come to be known as the "resistant black-scale infestation" in two definite areas of the southern California citrus district, fumigation operations were carefully checked during the season of 1920. The resistance of the scale was proven, and the necessity for improved dosage and improved methods was demonstrated.

Field demonstrations in mealybug and Argentine ant control were conducted throughout the infested citrus districts and have resulted in campaigns of eradication over a very large acreage. The success of the methods has reduced the mealybug menace to commercial control throughout the entire area. Manuscript on this subject has been submitted and is in the course of publication, as well as a paper on the control of the *citrophilus* mealybug. In cooperation with the Federal Horticultural Board a biologic study of the red date palm scale has been undertaken and experiments conducted in vacuum fumigation for the destruction of the scale on palm offshoots. Preliminary experiments indicate the possibility of controlling this insect by this method. Manuscript on the red date palm scale has been submitted and is now in the course of publication.

INSECTS AFFECTING CITRUS FRUITS IN FLORIDA.—The development of a combined oil-emulsion and Bordeaux spray to control insect pests and fungous diseases of orange and lemon groves has been studied. There exist in the Florida groves certain fungi which kill the white fly and various scale insects, and the studies of the above-mentioned combination spray have been complicated by this fact.

Work on the rust mite has been continued and marked progress has been made. Several forms of sulphur are being tested to learn their relative values. Experiments are under way with several new insecticides which seem likely to be useful in the control of various citrus insects.

The camphor thrips project, which had been carried on cooperatively with the Florida station, was taken over by the bureau laboratory. The biology of the insect has been worked out, and it has been found that the injury of the insect may be obviated by cutting the camphor trees back to the ground instead of pruning them back to stubs 4 or 6 feet in height. This pruning operation destroys the insects and has the advantage of permitting the trees to sprout at the crown roots.

The special investigation of the fungous diseases of insects attacking citrus fruits in Florida was begun during the summer of 1920. Two different species of fungi have been discovered associated with and apparently preying upon the rust mite, and studies are under way to determine whether these are parasitic, and if so how they can

be utilized in the control of the pest. A fungous disease of the citrus mealybug, first detected in 1917 in Louisiana, has been found to be largely responsible for the control of this pest in Florida. It kills young mealybugs before they can reproduce, and in fact one stage of the fungus occurs only in the young crawling individuals. A number of fungous diseases attack the white flies and scale insects of Florida, and these are also being studied in the hope that they may be used practically. One apparently new fact has been discovered in connection with the infection of white flies and of the purple scale by their fungous diseases, namely, that the infection takes place through the underside of the insects after they have become stationary, and does not regularly take place through the back. With this knowledge an increased efficiency of the disease should be gained by applying a spore-bearing spray at a time to insure maximum infection of the insects.

STUDIES OF GREENHOUSE INSECTS.—The strawberry rootworm continues to be a pest of much importance to roses under glass in certain regions of Pennsylvania, and in cooperation with the Bureau of Plant Industry of the Pennsylvania Department of Agriculture further important advances have been made in our knowledge of the biology of the insect, and especially of control methods. It has been ascertained that the adults are best destroyed by fumigation of the infested greenhouses with hydrocyanic-acid gas at the rate of $1\frac{1}{2}$ to 2 ounces of sodium cyanid per 1,000 cubic feet, with an exposure of two hours. Owing to the severe burning which accompanies this treatment, the hydrocyanic-acid gas should be used only during the "drying off" or resting periods. The method is suitable only for the single unit type of house. Dusting rows with sulphur and arsenate of lead (9 to 1) also showed promise as a repellent for the adults when applied after the rose bushes have been cut back and started for the ensuing season. For the treatment of the larval and pupal stages in the soil, wood ashes and tobacco dust applied alternately at 5-day intervals have given some benefit. This treatment should be applied soon after the egg-laying period has commenced, which is about the middle of March.

In addition to the principal work on the strawberry rootworm, studies have been made of the greenhouse leaf-tier. Experiments indicate considerable control by fumigating, dusting, dipping, and spraying. Dusting with sulphur and arsenate of lead has thus far given most encouraging results.

Additional data have been obtained on the general subject of fumigating greenhouses and the effect of same in the control of various greenhouse insects and on the plants treated. In the case of *Chrysomphalus biformis* on orchids the use of sodium cyanid at the rate of 1 ounce per 1,000 cubic feet of space with an exposure for one hour gave a mortality of from 98 to 100 per cent, with no injury to the plants. Similarly 98 per cent control of the greenhouse *Orthezia* was obtained and also with the black oleander scale, *Saissetia oleae*. It has been found practical to destroy the onion thrips on carnations by a fumigation with one-half ounce sodium cyanid per 1,000 cubic feet of space for a period of one hour. In addition to the control work above reported, necessary attention is being given to working out biologies and life histories of various greenhouse pests as a basis

for reducing their injuries. Much progress is being made in this general subject and its importance to the florist industry of the country warrants its enlargement.

INSECTS AFFECTING MANGO, GUAVA, AVOCADO, AND OTHER SUBTROPICAL FRUITS.—This investigation is being carried out, with headquarters at Miami, Fla., where unusual opportunities are present for its prosecution. Material progress has been made in the accumulation of knowledge concerning the various insect pests of the avocado, mango, papaya, etc., and manuscripts for Farmers' Bulletins have been submitted on the principal insect pests of the mango and of the avocado. A technical paper has been submitted for publication on the avocado red spider, *Tetranychus yothersi*. During the year a technical study of the avocado white fly has been continued, and many tests made with oil emulsions to determine what strengths are most efficient and economical. Other insect enemies of subtropical plants are being studied, as the avocado leaf-roller, the avocado leafhopper, the papaya fruit fly, etc. In addition to the biologic work under way, much time has been given to the development of sprays and other methods of control suitable for use on subtropical plants. Much of the water used in this territory is either brackish or contains bicarbonate salts, and oil emulsions are made with difficulty.

INVESTIGATION OF THE MEDITERRANEAN FRUIT FLY AND MELON FLY.—The work of this laboratory at Honolulu has consisted primarily of inspection and certification of pineapples, bananas, and taro for shipment from Hawaii to the mainland in cooperation with the Federal Horticultural Board. The demand on the office for inspection and certification of shipments has materially increased. Thus, about 160,000 bunches of bananas were passed for shipment to California, while several hundred bunches were condemned as unsafe for shipment. Several thousand crates of pineapples, taro, and other vegetables have been examined and certified as free from injurious insects.

As in previous years, careful daily records have been obtained of the extent of infestation of the different host fruits by the Mediterranean fruit fly and the percentage of parasitism of this fly by four species of introduced parasites, requiring much tedious attention. A manuscript on "Work and Parasitism of the Mediterranean Fruit Fly during 1919-20" is in the course of publication. In cooperation with the Office of Stored Product Insect Investigations of the bureau, investigations are underway of three species of bruchids of much importance to algaroba, the ground seed pods of which constitute a valuable stock food, and which is increasing in use. While certain parasites have been discovered attacking these bruchids, it is evident that additional parasites should be introduced to effect the control of the weevils in the field. Consequently an agent of the bureau has given special attention to searching for parasites in the southwestern parts of the United States. Much biologic and other information has been accumulated concerning the weevils, which will be of value in handling any parasites which may be introduced.

INVESTIGATION OF FRUIT FLIES AND OTHER TROPICAL AND SUBTROPICAL FRUIT INSECTS IN THE CANAL ZONE, PANAMA.—Work has been continued at this field station along the lines followed in the past. Close survey is maintained of the injurious insects of the region, especially to detect those recently established, in view of the large amount of

cargoes which pass through the canal from various parts of the world. Data are being accumulated on the life history, destructive-ness, and methods of control of various local and introduced insects, especially in view of the danger of their establishment in the United States.

INSECTS AFFECTING FOREST RESOURCES AND SHADE TREES.

The work of the branch of forest entomology has been continued under the supervision of Dr. A. D. Hopkins.

INSECTS AFFECTING FOREST TREES.—An especial effort has been made during the year to ascertain exact conditions throughout the western forests regarding the present situation relative to the damage done by the four most destructive insect enemies of North American forest trees, namely, the western pine beetle, the mountain pine beetle, the Black Hills beetle, and the southern pine beetle, and it is well to place these results on record here, although the discussion relates also to cumulative conditions during a period of years and to the rise and fall of what may be compared to epidemics.

The Pacific slope region.—The western pine beetle has continued to kill a considerable percentage of the largest and best yellow pine in the national forests, the national parks, the Indian reservations, and privately owned areas, especially in central to northern California and southern Oregon.

On the northern drainage of the San Juan River in California there is an area 20 miles long by 18 miles wide, including about 130,000 acres with a stand of about 2,000,000,000 board feet of timber, and in this area detailed studies have been made. The reports of the experts show that in the years 1913 to 1919, inclusive, there was an average loss in this area of about 4,800,000 board feet of pine timber annually, principally yellow pine, caused primarily by the western pine beetle. From 3,000,000 feet killed in 1913, the loss increased to 9,000,000 and then gradually declined to about 2,000,000 feet in 1919 and to less than 1,000,000 feet in 1920, which represents about an average minimum percentage of loss annually to the pine forests of the Pacific slope.

The results of investigations by the Bureau of Entomology and the Forest Service in Klamath County, Oreg., during the past year led to the conclusion that the damage done by the western pine beetle fluctuates from year to year between 0.1 and 0.3 of 1 per cent of the total value of the timber. It was estimated that on privately owned land only, this beetle kills from 7,000,000 to 24,000,000 board feet each year, and that within the portions of the three national forests and the Indian reservation contained in Klamath County 11,000,000 to 32,000,000 board feet are killed. This gives a total of from 18,000,000 to 56,000,000 feet and about 2,000,000 acres of yellow pine timberland in the county. In fact the amount of timber that will be killed by this beetle in Klamath County during 1921 will probably amount to over 56,000,000 board feet. It was also estimated that during the 10 years 1911 to 1920 the total timber loss was 3,000,000,000 having a stumpage value of over \$4,000,000.

These are two instances only; but throughout the pine timber area of the Pacific slope trees are dying each year as scattering in-

dividuals, with real epidemics here and there. Thus the loss is undoubtedly enormous. That it is a preventable waste is certain, since practical methods have been worked out and demonstrated by this bureau which, if put into effect, would prevent a large percentage of this loss.

In addition to the loss of yellow pine caused by the beetle in question, there is a proportionate loss of the best sugar pine caused each year by the mountain pine beetle. For example, out of a total volume of 247,470 board feet of infested yellow and sugar pine trees in the San Joaquin area actually counted and marked in 1919, 129,060 feet was killed sugar pine.

Northern Rocky Mountain region.—Reports from eastern Washington and Oregon and the whole of Idaho, Montana, and Wyoming show that the recent enormous losses of yellow pine from the western pine beetle, and of mountain or western white pine and lodgepole pine from the mountain pine beetle, have diminished to normal. There is, however, evidence of increased infestation in some sections of the forest, and now is the time for an organized cooperative effort to maintain the minimum loss and to act radically should an epidemic start.

Southern Rocky Mountain region.—Although the Black Hills beetle has in past years caused an enormous loss in Rocky Mountain yellow pine timber, there have been no late reports of extensive injury. This beetle, however, kills a large amount of timber in this region each year, and an extensive project, involving the Grand Canyon National Park and the adjoining national forests, is being inaugurated under the general advice of a representative of this bureau to take action toward reducing the prevailing losses from an endemic stage to a minimum normal.

Eastern States.—The condition is about normal. There have been a few sporadic outbreaks of the southern pine beetle in the pine timber of the Southern States, but this insect has not attracted much attention during the past year. There is, however, constant danger of an epidemic outbreak.

Partly through the dissemination of information on simple methods of control, the hickory barkbeetle, which severely damages hickory forest, shade, and nut trees in the East, has attracted very little attention during the past year.

CONTROL WORK AGAINST THE TREE-KILLING BEETLES.—There has been a greatly increased interest among Federal foresters and private owners in the practicability of control work. During the past year this work has been continued on one of the most extensive projects yet undertaken. This is known as the San Joaquin project, on which \$23,760 was spent up to the close of 1919. Since the epidemic character of the infestation was reduced to a minimum normal, attention has been directed to the maintenance of control by means of trap trees and the treatment of scattering infested trees in connection with the regular fire-patrol work.

The so-called Antelope control project is on private lands in northern California, and is being supervised by a representative of the bureau, who has charge of the field station at Ashland. The work during the past spring covered an area of 32 sections, and up to June 16 3,200 trees had been treated, an average of about 100 trees per section.

Largely through the initiative of the Klamath-Lake County Forest Fire Association of southern Oregon, an organization which previously expended more than \$25,000 in control work in the protection of yellow and sugar pine timber, the Legislature of Oregon passed a law at its last session requiring owners of timber to take necessary action toward the control of barkbeetles. The State legislature also forwarded a memorial to Congress which resulted in a special appropriation of \$15,000 to enable the bureau to cooperate with Federal and private owners and to furnish expert advice. A general conference was held at Klamath Falls, Oreg., on April 4 and 5, 1921, which resulted in the awakening of a widespread interest in the prevention of losses from insect damage to living timber on the Pacific slope and in the great encouragement of the forest entomologists of this bureau, who have deeply felt the apparent previous indifference of the lumber interests to the value of their work in establishing control methods. The efficacy of these methods has been demonstrated again and again, notably in northeastern Oregon and during the period of epidemics between 1900 and 1910 in the southern Rocky Mountain region; and that they have not been more generally adopted down to the present time is a grave misfortune.

INSECTS AFFECTING FOREST PRODUCTS.—Work on insects affecting forest products during the year has been limited to experimental tests with a large number of chemical sprays, submergence in water, seasonal cutting, etc., to prevent the serious damage by wood-boring insects to saw logs, lumber, and woods used in log houses and rustic work; the prevention of damage to wood in buildings, telegraph and telephone poles, etc., by white ants; and the prevention of damage to seasoned hardwood products by powder-post beetles.

The preventive spray which gave the greatest promise as a practical means of preventing the attack of destructive wood-boring insects in crude forest products is a mixture of creosote and kerosene.

Water submergence and sun-curing were found to be effective against nearly all wood-boring insects and are practical methods wherever sufficient water is available.

Sun-curing alone, by placing the logs on skids or platforms above the ground and turning them occasionally, proved quite effective and to a limited number of logs is practicable.

Seasonal cutting: It was found by cutting trees at different times in the year at the Eastern Field Station, East Falls Church, Va., that, in general, and for most kinds of trees and insects, those cut between the middle of July and the middle of August gave the best results in preventing damage by wood borers.

It now remains to test these methods on a commercial scale in cooperation with actual lumbering and wood manufacturing operations.

Termite or white ant damage to utilized wood products has, as in the past, received special attention. Eighty-nine cases of damage to buildings and their contents in the United States were reported during the year; 17 of them were within the District of Columbia, and 16 from Indiana. The other reports included cases in the States of Alabama, Arkansas, California, Florida, Illinois, Iowa, Kansas, Louisiana, Maryland, Missouri, New Jersey, North Carolina, Ohio, Oklahoma, South Carolina, Tennessee, Texas, and Virginia. In addition 9 cases were reported from other countries. A few cases of

special interest were damage to woodwork and stored books in the Library of Congress, flooring and stored material in the basement of the New National Museum, post cards in the post office at Elizabeth, N. J., and woodwork and contents in a building of the Union Stock Yards at Wichita, Kans.

It was found that in all cases the damage by this class of insects was largely, if not entirely, due to improper construction which allowed the entrance of the insects. It has been found that, in order to prevent damage, all woodwork in the foundation and basement floors must be completely protected by chemical treatments or concrete of a fine texture closely packed next to all woodwork. Cracks or openings through coarse unpacked concrete, allowing passageways for the insects from the ground, are often the source of the trouble.

Powder-post beetle damage to seasoned, stored, or utilized hard-wood products, such as ash and hickory handles, and wagon, automobile, and airplane stock containing sapwood, is a common source of serious loss and expense throughout this and other countries. Forty-four cases were reported from the United States, 22 of which were damage to woodwork of buildings and furniture and 22 to seasoned lumber, vehicle stock, implement handles, veneer, walnut gun, and airplane stock, and blocks of briar wood from which pipes are manufactured.

Investigations during past years have shown that damage by powder-post beetles can be prevented by methods of handling the material and simple treatments of the wood by linseed oil, kerosene, etc., full information on which has been widely disseminated through publications and correspondence.

Sound wormy chestnut is of special value as a core or base for veneer work, but there is a prejudice against its use by some manufacturers in this and other countries because of the mistaken notion that it contains insects which will continue the damage. This damage is caused in the standing trees and logs, so that there is absolutely no danger of continued damage after the wood is seasoned. Information to this effect is contributing to confidence which will ultimately result in an increased demand for the immense amount of available sound wormy chestnut wood from trees killed by the chestnut blight.

INSECTS AFFECTING SHADE TREES AND HARDY SHRUBS.—Very limited funds were available for this work, and for the Eastern States it has been confined almost entirely to giving information by correspondence in response to a greatly increased number of inquiries. Much attention, however, has been given to field work, remedial experimentation, and biological studies at the field station at Los Gatos, Calif. The insects especially studied have been a bark scale on the Monterey cypress, the scale insects affecting hedge plants, the California oak worm, the twig girdler of the live oak, and a flat-headed borer which seriously damages shade and fruit trees, shrubs, and ornamental vines. With all these insects practical control means have been found. The European elm scale, seldom very serious in the East, has recently been accidentally introduced into the far Western States and there has become a serious pest. Elm trees have been planted extensively and are weakened and sometimes killed by this insect. A simple remedial treatment has been found which consists in a thorough washing of the trees by means of a fire equipment or a

power spray with plain water *at the time when the leaf buds are opening.*

Much work should be done with many of the shade-tree insects of the East, but funds are lacking.

THE BIOCLIMATIC LAW.—Intensive research work has been continued by Dr. Hopkins on the bioclimatic law, which was mentioned in my last annual report. Notable progress has been made in demonstrating that this law is applicable to all continental and insular areas of the world, with special reference to the studies of broad fundamental problems of agriculture, including those relating to entomological research and practice. For example, one of the most important problems for the consideration of entomologists relates to the introduction of insect pests from one part of the world to another. It is largely a question of the relations between life and climate—as to the environment of the original home of a species, the climatic range and limits of its natural distribution and that of the plant or animal on which it lives in one country, the place of its introduction into another, and the range and limit of similar climate and food conditions which are favorable for its natural or artificial spread from the point of entry. Through a knowledge of the natural laws and principles involved and of the history of past introductions of pests into this country, it is possible to predict as to the dangerous pests to be guarded against in the future, the places and regions in which they may become established if introduced, and the extent to which they may or may not spread.

It is evidenced that, through the knowledge to be gained by the application of the law, predictions could be made that would serve as reliable guides to the action to be taken to prevent both undesirable introductions and the expenditure of large sums of money in useless efforts to prevent introductions or spread in sections of the country where the insect, plant, or disease could not survive.

It seems, looking at it in a broad way, that this law has a worldwide application to problems that have not been solved and evidently can not be solved by any other method short of expensive explorations and detailed studies of local conditions.

BEE-CULTURE INVESTIGATIONS.

The work of the office of Bee-Culture Investigations, under the supervision of Dr. E. F. Phillips, has been modified during the year to return to investigational work, which was interfered with so greatly during the period of the war. The educational work which was begun during the war proved so helpful that some of this work has been continued and will doubtless form part of the regular work of the office in the future. The laboratory and apiary are still located at Somerset, Md., near Washington.

DEMONSTRATIONS IN BEEKEEPING.—The funds available for this work were still further reduced this year to provide additional funds for research work. The office is cooperating with six States in extension work in beekeeping, in all cases at least half of the funds being provided by the respective States. The extension work has been along the lines mentioned in detail in former reports, and emphasis is placed on the improvement in the methods of those bee-

keepers who are making this their life work, rather than to encourage a large number of persons to take up the keeping of bees. Specialization in beekeeping became more than ever pronounced during the war, and with a return to more normal conditions it is believed that it is only the well-informed specialist who can successfully produce honey at the prices offered for the product.

The extension short courses mentioned in earlier reports have been reduced in number, due to the greater emphasis on research work on the part of the men in the Washington office, and but one was given during the year. Because of the insistent demand for help of this kind it will be necessary for a number of years to hold such short courses, and several have already been requested for the coming season. The average attendance of all the short courses held by this office is well over 100 commercial beekeepers, who come to spend a full week studying the specialized problems of the beekeeper.

During the year an outline of a year's work for bee clubs was completed and is about ready for publication. It is believed that this will greatly stimulate interest in this branch of agriculture and will result in the development of better beekeeping methods than are in vogue in certain parts of the country.

The bulletin on swarm control (Farmers' Bulletin 1198), mentioned in the last report, has been completed. Three manuscripts for Farmers' Bulletins have been submitted for publication during the year, which differ from any of the previous publications of this office. It has been the experience of the office that in bulletins in which general principles underlying beekeeping practices are presented many beekeepers fail to choose the method best suited to their local conditions, and because of the plan of presentation many make no change in their methods. To overcome this difficulty the bulletins have been prepared giving specific directions for all phases of beekeeping for the white clover, buckwheat, and tulip-tree beekeeping regions. These regions cover the chief beekeeping territory of the part of the United States east of the Mississippi River. As soon as possible it is planned to prepare other bulletins for additional beekeeping regions of the country.

The correspondence of the office continues to be extensive. During the period of the war there was an enormous increase in the number of requests for information on all phases of beekeeping, and after the war there has been only a partial reduction to prewar conditions. It is a noticeable phase of the correspondence that more and more the requests for information are coming from specialists in beekeeping rather than from persons about to take up beekeeping.

Following the promulgation of the Postal Regulations of May 3, 1921, requiring that the candy used in mailing queen bees from uninspected apiaries be made from honey which has been boiled for 30 minutes in a closed vessel, queen breeders throughout the country have had considerable difficulty in making a satisfactory candy. This trouble has increased until during the summer of 1920 the losses ran into thousands of dollars. The problem of making a satisfactory candy for this purpose was taken up in cooperation with the carbohydrate laboratory of the Bureau of Chemistry, and Mr. Jay M. Smith was given a temporary appointment for this work. It was found that the trouble arises from the fact that the mixing of the

honey and powdered sugar is done at too high a temperature, and an article has been prepared for publication in one of the bee journals giving the results of this work, including detailed directions for making a satisfactory candy for mailing queens.

From time to time reports have appeared in beekeeping publications to the effect that honeys produced from certain nectars are poisonous to human beings, but up to the present it has been impossible to get data on which one could say positively that this is true. During the spring of 1921 several such reports came to the office and samples of honeys were obtained. Mr. Jay M. Smith took up a study of these honeys with a view to the isolation of the poisonous principle if present. This work is not yet completed, but there is reason to believe that there is such material present because of the physiological effects which these honeys have had on persons who have eaten them. If this work shows the presence of poison, it will then be necessary to devise a method of beekeeping for the region in which this is found, which will result in all of this honey being consumed by the bees in brood rearing, the hives being emptied before any other honeys are gathered.

WINTERING OF BEES.—As was explained in the last annual report, the work on the behavior and care of bees in winter was followed by a careful survey of the condition of the colonies in early spring and later throughout the early summer to see how their development was influenced by the various methods of wintering. During the spring and summer of 1920 careful measurements of the colony population and the amount of brood were taken on five colonies at intervals of a week. As no work of this kind had been done previously, one of the first things to be determined was a method for measuring the brood, and the results for the first season were not entirely satisfactory because the colonies were all weakened by the manipulation. Beginning with the first brood-rearing in the spring of 1921, this work was taken up again with different methods and is still under way. This is being done on 16 colonies at intervals of a week and the colonies have not been modified in their development by the methods now in use. Careful records are also being kept of the changes in the honey flow and of the various climatic conditions, so that it may be determined to what extent these factors influence the development of the colony. This work was begun in 1920 by Mr. Lloyd R. Watson and is being continued by Mr. Willis J. Nolan. Since this problem has many applications aside from the checking up of the wintering results, the project under which it is being done has been changed and it will be continued under the project "Behavior of bees."

DISEASES OF BEES.—During the year announcement was made of the discovery of the cause of the disease of adult bees known in Great Britain as the Isle of Wight disease. Since it was not known whether this disease exists in the United States it was thought best to make an immediate survey to determine this point, and work was begun on this June 1, 1921, by Mr. J. B. Moorman. Beekeepers throughout the United States were requested to send to the bureau samples of adult bees which seemed to be suffering from any disease whatever, and as a result of this request a large number of samples have been received. So far no bees have been received in which the mite causing the disease in question, *Tarsonemus woodi*, has been

found. In connection with this work the anatomy of the thorax of the worker bee is being more carefully studied than has before been possible. The receipt of such a large number of samples of adult bees has greatly increased our knowledge of the distribution of Nosema disease, concerning which but little has been determined. During the year 1,100 samples of diseased and suspected material have been received from beekeepers and apiary inspectors, the largest number in the history of the office. This increase is doubtless due to the campaigns carried on by the several States for the eradication of these diseases, and is not interpreted as showing any increases in the diseases of bees.

The work on the distribution of European foulbrood from the records of 15 years' work in the office, mentioned in the last report, has been continued and will soon be completed for publication. Because of the finding that this disease can not continue to do damage in localities where there is a regular and heavy honey flow early in summer, it has seemed desirable to make a preliminary survey of the country to determine in what places this disease is doing damage, and this has entailed a general survey of the bee-keeping regions throughout the country. This material will be presented for publication soon, in so far as it has to do with the control of this disease, but because of the far-reaching importance of such a survey it is planned to continue the work under a new project, "Beekeeping regions of the United States," rather than to do all the work of this character under the "Disease" project.

It was found in the wintering investigations that during the winter months bees literally wear themselves out in heat production, and that the death of bees during this time must be attributed to this work. In order that the effects of this work be known, work was begun in June, 1921, on the problem of aging adult bees, the work being done by Mr. A. D. Shaftesbury. Beekeepers have long known that the aging of bees is determined by the work which they do rather than by days or weeks, and the purpose of this investigation is to learn what organs are affected by this work. It is impossible even to predict whether such knowledge will enable us to decrease the damage to the several organs affected. With the beginning of the fiscal year 1921-22 this work was transferred to the project "Physiology of bees."

PRESENT STATUS OF BEEKEEPING.—Honey production, like most other branches of agriculture, has suffered from the depressed condition of the markets, and the beekeeping industry is now passing through a serious crisis. Those beekeepers who produce the honey crop of the country are chiefly specialists, which means that they are one-crop farmers, and like other specialists in agriculture they have suffered more from the decline in prices than have those who diversify their production. In spite of this situation it is still believed that specialization is the only proper way to conduct the beekeeping of the country, in so far as the production of the marketed crop is concerned, and the commercial beekeepers of the country are giving serious attention to the problems which have arisen from the price decline. The estimates of honey production and the semimonthly honey market news service, issued by the Bureau of Markets and Crop Estimates, are of inestimable value in a time such as this.

INSECT PEST SURVEY.

The Bureau of Entomology, at the suggestion of the State agricultural experiment station and university entomologists, has instituted the Office of Insect Pest Survey, in order that both the bureau and these outside workers might be kept more closely in touch with entomological conditions throughout the country. The work was started in March under the supervision of Mr. J. A. Hyslop.

The object of the survey is to collect scientific data on insect conditions throughout the country, to study this data from month to month and year to year with relation to the several factors that cause insect outbreaks, and to prepare this information in the form of publications for the immediate use of all entomological workers throughout the country.

The survey obtains its information from 59 collaborators located in the several States; these are largely entomologists of the agricultural experiment stations, State entomologists, and entomologists in the State universities and agricultural colleges. Each collaborator assumes responsibility for collecting information on all insect outbreaks within his respective territory and transmitting this information to the central office in Washington, where it is digested, correlated, and edited for publication.

The survey issues a monthly bulletin of from 20 to 40 pages on the insect conditions of the preceding month. Reports of serious outbreaks are published as soon as received, in the form of special reports for the immediate information of working entomologists in near-by States, in order that they may be forewarned of possible outbreaks in their territory, and very urgent news is sent out in the form of a telegraphic emergency report. An annual summary of the year's insect conditions correlated with the weather conditions and other factors which influence insect abundance will be prepared, and in this summary an attempt will be made to give an estimate of the financial and material loss occasioned by insects.

Up to the present date the survey has issued 4 numbers of the bulletin, 15 special reports, and 1 telegraphic emergency report. It has received over 2,500 reports of insect outbreaks from its collaborators. Of these reports 1,005 were on fruit insects, 590 on truck-crop insects, 465 on cereal and forage crop insects, 249 on forest and shade-tree insects, 73 on greenhouse and ornamental plant insects, 53 on southern field-crop insects, 45 on insects affecting man and domestic animals, and 8 on insects infesting stored products.

REPORT OF THE FEDERAL HORTICULTURAL BOARD.

UNITED STATES DEPARTMENT OF AGRICULTURE,
FEDERAL HORTICULTURAL BOARD,
Washington, D. C., October 1, 1921.

SIR: I submit herewith an executive report covering the administration of the plant quarantine act for the fiscal year ended June 30, 1921.

Respectfully,

C. L. MARLATT,
Chairman of Board.

Hon. HENRY C. WALLACE,
Secretary of Agriculture.

LINES OF WORK.

The work of the board may be classified as follows:

1. The administration and enforcement of the miscellaneous foreign and domestic quarantine and other restrictive orders listed at the end of this report.
2. The port inspection service maintained as an essential part of the enforcement of the several foreign quarantines and restrictive orders.
3. The administration of special appropriations by Congress for the control or extermination of newly established plant enemies. Of these the appropriation for the pink bollworm of cotton, the potato wart disease, and the date scale are administered directly by the Federal Horticultural Board. Other similar appropriations made to the Bureaus of Entomology and Plant Industry of the department, involving quarantine control of new pests, are enforced under the authority of the plant quarantine act by the bureaus concerned in cooperation with this board. These include appropriations for the gipsy and brown-tail moths, the Japanese beetle, the European corn borer, the Mexican bean beetle, the white-pine blister rust, and the black stem rust, and foreign quarantines supplementing domestic State quarantines with respect to citrus canker and the flag smut and take-all diseases of small grains.

These activities have been rather fully recorded in the Service and Regulatory Announcements of the board issued during the year, and these announcements, therefore, constitute an available record in detail of the work of the board. This annual report is limited to a general discussion of the more important only of these activities.

THE PINK BOLLWORM.

The pink bollworm has gained slight foothold in one new State, namely, New Mexico, and its area has been extended somewhat in Texas, but has been very much reduced in Louisiana. A brief outline of the existing status follows.

STATUS IN TEXAS.

There are five areas or districts in Texas which are either now or have been in previous years infested with the pink bollworm, namely, the Hearne, Trinity Bay, Pecos Valley, Great Bend, and El Paso districts. The Hearne and Trinity Bay districts were original centers of infestation and the others are of later origin.

The Hearne district has been maintained as a noncotton zone from the beginning (1917), and this district is now believed to be entirely free from the pest.

The Trinity Bay district has been very greatly reduced, both as to area and amount of infestation.

The El Paso infestation, determined late in October, 1920, extends along the Rio Grande Valley from somewhat north of El Paso in Dona Ana County, N. Mex., through El Paso and Hudspeth Counties, Tex. The extensive plantings of cotton in this district in 1920, followed some very limited plantings of 1919, and the infestation undoubtedly resulted from infested cotton seed brought to the Mexican border at Juarez and from the irregular movement of Mexican laborers across the border, carrying more or less cotton and cotton seed.

The Pecos Valley district was substantially freed from the pest in 1919, but a single infested plant and a single insect being found in connection with the crop of that year. Some slight reinfestation was determined late in 1920 at a number of points in this area in connection with the crop of that year, and a jump from this infestation was determined at Carlsbad, N. Mex., in the extension of the Pecos Valley into that State.

No cotton was grown in the Great Bend district in either 1919 or 1920.

Of these five areas of infestation, the Hearne area has been apparently freed from the pest. The others, with the exception of the new El Paso region, were very substantially freed from the pest during the period when partial enforcement of noncotton zones and control work were possible under State law. The reappearance in three of the older districts is a perfectly natural result of the failure to carry out the full program of extermination, including enforcement of noncotton zones for all infested areas.

STATUS IN LOUISIANA.

The prompt and efficient work of Louisiana, in cooperation with the Federal authorities, has produced a very favorable outlook for the extermination of the pest in that State. The three parishes determined as infested in 1919 were maintained as noncotton zones in 1920, with thoroughgoing cooperation on the part of the State and planters, and have been continued as such for 1921 as to all the areas actually known to have been infested in 1919. The areas about the five towns which were under suspicion because of a shipment of seed to oil mills have been under regulation. The only infestation as a result of such movement of seed was the infestation determined late in 1920, in the vicinity of Shreveport. Thoroughgoing clean-up operations were given to this district in the following winter of 1920-21 and this new invaded area was also maintained by the State as a noncotton zone for 1921.

STATUS IN NEW MEXICO.

The extension of the El Paso district north of El Paso into New Mexico and the invasion at Carlsbad in the Pecos Valley, both relate to areas of cotton grown under irrigation and are therefore possible of efficient control under adequate State authority and support.

FEDERAL ACTIVITIES.

The effort joined in by the department to get adequate legislation from the State of Texas to keep up the program of extermination failed with respect to the regular session of the legislature, which convened early in 1921. As a result of this failure and the impossibility under the then existing State law of carrying on effective control work in Texas, a pink-bollworm conference was called at Washington for May 16, 1921, for the purpose of considering how best to prevent the spread of this pest from Texas to other cotton-producing States. This conference was attended by quarantine officers, representatives of the important agricultural organizations, and many individuals from practically all of the States interested in cotton culture. In its report this conference voiced the conviction that there is still a possibility of eradicating the pink bollworm in the United States through the establishment and maintenance of noncotton zones. It further recommended that funds for compensating farmers in non-cotton zones be supplied under adequate safeguards jointly by the State and Federal Governments.

On the promise of the Texas representatives at the conference that a strong and united effort would be made to secure adequate pink-bollworm legislation for that State, including the compensation feature, at a special session of the legislature which was called for July, and following the recommendation of the conference, this department requested authority from Congress to use not to exceed \$200,000 of the existing pink-bollworm appropriation to participate with the States in compensation of farmers in noncotton zones. This recommendation was favorably acted upon by Congress in the joint resolution of August 9, 1921. This resolution provides that the Federal payments shall be limited to the actual and necessary loss incurred by the farmer, shall in no case exceed \$5 per acre, and shall not be more than one-third of the amount paid by any State, and that no reimbursement shall be made in respect of any farmer who has not in good faith complied with all State and Federal regulations.

The special session of the Texas Legislature, in July, again took up the subject of pink-bollworm legislation and passed a law in which many of the defects of previous pink-bollworm legislation are corrected. This law provides for cooperation with the United States Department of Agriculture and for compensation to planters in non-cotton zones on the basis of actual loss incurred.

The Federal quarantine action on account of the pink bollworm has been extended to cover the new infestations by this pest in western Texas, in New Mexico, and at Shreveport, La. Based on adequate State support and cooperation, it is proposed to limit the quarantine restrictions in these States to the areas actually invaded.

THE OUTLOOK.

The future menace of the pink bollworm to the cotton crop of this country had been fully indicated by the records of this pest in Egypt, Brazil, Hawaii, and Mexico. A question as to the importance of this pest to the cotton crop of Texas and the South, which naturally arose in the minds of the planters on account of lack of adequate acquaintance with it, has been largely removed as a result of the report of a commission organized by the Texas Chamber of Commerce in November, 1920, to investigate and report directly to the governor on the pink-bollworm situation in the Laguna district of Mexico. This commission, made up of representatives of a number of State-wide agricultural and cotton associations, after minute field examinations in the Laguna, submitted a report to the governor, indicating a loss of at least 50 per cent of the crop of that district due to the pink bollworm.

Up to this time the effort of this department, in connection with the States concerned, has been to eradicate the insect. Undoubtedly any attempt to control the pest in connection with the continuation of the growth of cotton in areas actually infested will be followed by the inevitable increase of the pest in such areas and its ultimate spread throughout the South. That extermination is still possible is the belief of the experts, Federal and State, who have given careful consideration to the subject. Such extermination, however, is necessarily conditioned on adequate State cooperation, both legal and financial, and the adoption and enforcement without interruption for a period of years of the policy of noncotton zones for invaded areas.

With respect to the growing crop of cotton of 1921, at the time of writing this report (Oct. 1, 1921) it is too early to determine the possible reappearance of the pest in the invaded districts. In view of the incipiency of the infestation in these districts, it is not easily possible to find infestation until the late fall and winter examinations. A single infestation has, however, been recently reported from the Trinity Bay district. The scouting and field work during the next three or four months (October-January) should fully bring out the status of this pest with respect to the crop of 1921.

RESEARCH WORK IN MEXICO AND ELSEWHERE.

Early in the year 1921 the board resumed the research work on the pink bollworm in the Laguna, Mexico, which had been interrupted for a short time. A laboratory has been established on a typical plantation where the management provides every facility for the work of the three investigators stationed there. An important feature of this work is to obtain information regarding the life history and habits of the insect which will be of help in the quarantine and eradication work under way in Texas. Methods of reducing damage are being studied which may be applicable in the United States in case the effort to eradicate the pest here fails. These include experiments with poisons along lines suggested by the recent success of the Bureau of Entomology in controlling the cotton-boll weevil, and the disinfection of seed by heat. Another line of work consists of studies of the relation between earliness of maturity and damage by the insect. For the purpose of these studies a number of the principal early-maturing varieties cultivated in the United States were planted at the station.

A bulletin reporting fully on the previous research work in Mexico was published by the department during the season.

On account of reports coming to the department about the occurrence of the pink bollworm in certain of the West Indian islands, an agent is now studying the origin and extent of the infestation in these islands and obtaining such additional information as may be of use in protecting this country from new infestations from this source.

PORt AND BORDER CONTROL TO PREVENT REENTRY OF PINK BOLLWORM.

The control which is now being exercised at border ports to prevent the reentry of the pink bollworm involves not only the Mexican-border control, which covers practically all freight and traffic entering the United States directly from Mexico, but also the northern ports of entry for foreign cottons. With respect to such northern ports, there are now in operation seven vacuum fumigation plants privately owned for the disinfection of imported cotton, viz, Boston 2, New York 2, Seattle 2, and Oakland 1. An additional plant at New York is now in course of construction and will shortly be put into operation. From March 10, 1916, to June 30, 1920, 1,503,622 bales of imported cotton have been disinfected at these fumigating plants under the strict supervision of inspectors of the Federal Horticultural Board. (See pp. 11-12.)

On the Mexican border, fumigating houses which will accommodate from 1 to 15 freight cars have been erected by this department at four of the principal ports of entry. A similar house for the fumigation of wagons, automobiles, etc., has also been constructed at Del Rio, Tex., and a 14-car fumigation house is being erected at Nogales, Ariz.

Federal plant quarantine inspectors are now stationed at all of the important Mexican border ports of entry in Texas, Arizona, and California. During the period under review, 25,972 cars were carefully examined in the freight yards of the Mexican towns opposite the American ports of entry, to determine their freedom from cotton seed, and of this number, 15,524 were fumigated with hydrocyanic-acid gas, immediately upon crossing the border, in houses constructed for the purpose. At Del Rio, Tex., where there are no railroad connections with Mexico, 22,595 vehicles of various descriptions were inspected, 23 of which were fumigated on account of the presence of cotton seed.

A fee is collected for the fumigation of the cars, representing approximately the cost of the chemicals and labor incident to the operation of the houses. This cost, however, does not include the salaries of inspectors. From October 1, 1919, to June 30, 1921, \$96,299.50 has been collected from such fees and turned into the Treasury.

The inspection work at the footbridges in cooperation with the customs officials located in Brownsville, Laredo, Eagle Pass, and El Paso, Tex., as well as the boundary line at Nogales, Ariz., has been continued, and numerous interceptions have been made. Such examinations have been not only for the purpose of controlling the possible entry of cotton and cotton seed, but also for the enforcement of other quarantines involving Mexico on account of fruit flies and insect or disease enemies of various crops. A total of 28,048 interceptions of contraband material have been made as follows: Avocados, 7,072; oranges, 3,563; mangos, 1,839; sugar cane, 3,326;

cotton, 1,954; corn, 1,988; sweet limes, 1,347; potatoes, 625; peaches, 1,274; guavas, 2,039; sapotes, 207; plums, 245; sweet potatoes, 357; grapefruit, 412; and miscellaneous plants, 1,799.

THE EUROPEAN CORN BORER QUARANTINE.

The determination of the occurrence of the corn borer over wide areas in the Province of Ontario, Canada, made it necessary to amend the foreign quarantine relative to this pest so as to bring under restriction importations from Canada of various products in addition to corn which are known to be possible means of spreading this pest. Following the hearing of June 28, 1921, such revision was issued effective July 21, 1921.

The regulations under the domestic European corn-borer quarantine were amended effective January 15, 1921, to eliminate, during the period from January 1 to June 1, the requirement of inspection and certification of celery, green beans in the pod, beets with tops, spinach, rhubarb, and oat and rye straw as such or when used as packing. There appeared to be no risk, during this period, from such products, even though grown in the infested area, of distributing the corn borer, and the action was taken to eliminate the cost of inspection during the season indicated.

The corn borer was determined late in 1920 as occurring in Maine, adjacent to the infested districts in New Hampshire and Massachusetts. A thoroughgoing clean-up was made of the infested area and no recurrence has been so far determined for 1921.

During the summer (1921) the corn borer was found to be established on a series of islands crossing Lake Erie, evidently infested from the Ontario section, and possibly crossing in this manner had effected a foothold in 26 Ohio townships bordering the lake, extending to within about 60 miles of the Indiana line. A similar infestation probably originating from the western New York area, was determined in the Pennsylvania district adjacent to the lake, involving 11 townships. The infested area in western New York now numbers 14 townships.

Following the determination of the infestation of these new districts, an important conference on the European corn borer to discuss future policy was conducted under the auspices of the United States Department of Agriculture at Sandusky, Ohio, September 15 and 16, participated in by the State entomologists and agricultural control officials of many of the Eastern and Middle States. As a follow-up to this conference, a formal hearing has been called for October 11 in Washington to consider further Federal quarantine action which may be advisable with respect to this pest in view of the important change in the situation indicated by its spread as now determined.

MODIFICATION OF THE GYPSY MOTH AND BROWN-TAIL MOTH QUARANTINE.

An informal conference on the gypsy moth and brown-tail moth was held in Washington May 27, 1921. Following this conference the quarantine (No. 45) with respect to these pests was amended June 8, 1921, effective on and after July 1, 1921, to make the quarantine lines correspond with the spread or recession of these insects dur-

ing the previous 12 months. During this period (1920) there was considerably more spread westward of the gypsy moth than had been the case in several previous years. This extension necessitated the inclusion of 62 new towns distributed throughout New Hampshire, Vermont, Massachusetts, and Connecticut.

As had been the case during recent years, it was possible to make a considerable reduction in the area quarantined on account of the brown-tail moth. A good deal of this decrease is due to the energy of the citizens in clean-up work, to the action of parasites, and to the heavy winter killing of the larvae in the webs.

With respect to the new areas in New Jersey, New York, and Pennsylvania, which were determined as infested in 1920-21 by the gypsy moth, it was believed that the quarantine and control action which had been taken by these three States with respect to the known infested area made it unnecessary at this time to extend the Federal quarantine to these States, particularly as the enforcement of the State quarantines was being maintained in close cooperation with the Federal Horticultural Board and the Bureau of Entomology of the United States Department of Agriculture. A fully explanatory statement on the existing State and Federal control was issued for the information of the State quarantine officials.

The origin of the infestation in New York, New Jersey, and Pennsylvania, with minor exceptions, is clearly traced to the importation of an enormous block of blue spruce from Holland for ornamental plantings by a large estate near Somerville, N. J., shortly prior to the enactment of the plant quarantine law of 1912. The insect thus introduced had slowly developed in the center of this block of blue spruce and had begun its rapid spread only a year or two before the discovery of the infestation in 1920. The other points of infestation in New Jersey, New York, and Pennsylvania were clearly traced to shipments of blue spruce from this original source of infestation. This history is a very significant illustration of the risks from the large importations of ornamentals of this sort which had been made in past years for the adornment of private estates and which are now fully controlled under the enforcement of a quarantine very much limiting and regulating the entry of such stock.

THE JAPANESE BEETLE QUARANTINE.

The Japanese-beetle quarantine is being enforced by the Bureau of Entomology in cooperation with this board and with the States concerned, New Jersey and Pennsylvania. A revision of this quarantine was issued effective December 1, 1920, limiting the requirements of inspection and certification with respect to cut flowers to the period between June 15 and November 1. The Federal quarantine has been supplemented by quarantines of like provision issued by these States providing for intrastate control.

At the close of the season of 1920 the area known to be infested by this beetle covered approximately 81 square miles in New Jersey and 10 square miles in Pennsylvania. This territory includes in New Jersey 1,075 farms shipping produce and 89 nurseries and greenhouses shipping various products, and in Pennsylvania 550 farms and 128 nurseries.

The object of the Federal and State quarantine-control action with respect to this pest is to limit or delay spread. The habits of

the insect are such that efforts to prevent local spread can never be made highly effective, and it is perfectly apparent that a pest of this character once introduced and fairly firmly and widely established must be reckoned with sooner or later as a permanent tax on the agriculture of the country. The justification for the continuance of the Federal and State quarantine work is determined by the amount of repression which it is possible to effect by such control, but this pest may reach at any time a stage where such control can not be continued with profit. The hope, therefore, in the future is in the determination of direct control measures by spraying or other means and by the introduction and encouragement of natural enemies.

THE DATE-SCALE QUARANTINE.

The Federal Horticultural Board, in cooperation with the Bureau of Plant Industry of this department, has been conducting work looking to the extermination of two important date scales which menace the future successful development of the date industry in southern California and Arizona. The work already done indicates that complete eradication of at least one and perhaps both of these pests can be accomplished if it is made possible to inspect the groves as frequently as necessary and to burn the infested outer portions of, or otherwise clean, the infested plants. To bring this work of control and extermination to a conclusion Congress was asked for a specific appropriation of \$15,000, of which \$5,000 was to be immediately available. Under this appropriation this work has been reorganized and placed on a much better basis. It involves both the practical field work of extermination and also provision for a biological study of these pests. The latter feature of the work is being conducted in cooperation with the Bureau of Entomology.

THE CITRUS BLACK-FLY QUARANTINE.

The occurrence of an important pest of citrus and many other plants, the citrus black fly, in Cuba, the Bahamas, Jamaica, Canal Zone, and other countries, led to widespread fears that this pest might gain entrance into Florida and other citrus regions of the United States through the agency of imported fruits and vegetables. Following a hearing on this subject conducted at Washington, December 20, 1920, a quarantine was promulgated February 16, 1921, effective on and after April 1, 1921, under which the entry of fruits and vegetables is regulated from Cuba, the Bahamas, Jamaica, Canal Zone, Costa Rica, India, Philippine Islands, Ceylon, and Java. This quarantine applies to fruits and vegetables in the raw or unprocessed state and to plants or portions of plants used as packing material in connection with the shipment of such fruits and vegetables. An important feature of the quarantine is to provide for the movement of clean fruit and vegetables—in other words, uncontaminated with leafage or other portions of plants which are apt to convey the black fly. This quarantine places no real bar on the movement of fruits and vegetables from these countries, but provides for desirable cleanliness in connection with shipments both as to the containers and to the carriers—cars or ships. Hearty cooperation in the enforcement of this quarantine is being had with Cuba and the other principal countries and islands con-

cerned to the south of us. Detailed instructions for the enforcement of this quarantine and regulations thereunder have been distributed and are given permanent record in the Service and Regulatory Announcements.

THE MEXICAN BEAN BEETLE QUARANTINE.

The Mexican bean beetle, which had been a rather important enemy of the bean crop for many years in New Mexico, Arizona, and Colorado, and was supposed to be rather climatically limited to that general region, suddenly developed wide foothold in the State of Alabama, supposedly carried to that State in shipments of western alfalfa hay. At the earnest request of the authorities of that and other States, a Federal quarantine was declared covering the invaded area in Alabama and an appropriation was given to the Bureau of Entomology of the department for the enforcement of this quarantine in cooperation with the State authorities and this board. A Federal quarantine on account of this pest was promulgated April 8, 1921, effective on and after May 1, 1921, following a public hearing in Washington October 11, 1920.

As a result of surveys conducted during the spring and summer of 1921, it developed that this pest not only involved a much wider area in Alabama than had been previously determined but that it also occurred in the States of Georgia, Tennessee, Kentucky, and South Carolina, indicating a possibly fairly general dissemination throughout the South beyond any hope of extermination or even effective quarantine control, and with the approval of the States concerned, the Federal quarantine was revoked July 23, 1921.

THE CITRUS FRUIT QUARANTINE.

The canker disease of citrus fruit was officially reported to the board as occurring in Australia. It therefore seemed desirable to extend the existing quarantine to cover not only Australia but also Tasmania and New Zealand on account of the close commercial relations between these three countries. To consider the advisability of extending this quarantine, a call was issued for and a public hearing was duly conducted in Washington July 19, 1921. Quarantine action has been deferred to give opportunity to secure some additional information which is needed.

The existing citrus-fruit quarantine on account of the canker disease promulgated June 27, 1917, covers eastern and southeastern Asia, the Malayan Archipelago, Philippine Islands, Oceania (except Australia, Tasmania, and New Zealand), Japan (including Formosa and other islands adjacent to Japan), and the Union of South Africa. During the past year citrus canker has been taken on grapefruit and oranges from China and India on several occasions at the port of Seattle.

THE POTATO WART DISEASE.

The extensive surveys conducted in 1920-21 have pretty well eliminated the chance of country-wide infestation at this time by the potato wart disease, and it seems to be pretty clearly established that the disease is now limited to comparatively small areas in the States of Pennsylvania, West Virginia, and Maryland. The only

new infestations are those determined in three villages near Frostburg, in western Maryland, which lie practically between the western Pennsylvania and the West Virginia infested districts, and are similarly mining sections. Some one thousand individual garden plats in these three States have been determined as infested, but the total areas of these plats aggregate less than 100 acres. The three invaded States are enforcing effective quarantine measures, and as these seemed adequate for the protection of surrounding States, no domestic Federal quarantine on account of this disease has been promulgated.

The survey work to determine spread or possible new centers of infestation and the research work with respect to the disease and its control have been carried on as heretofore in cooperation with the Bureau of Plant Industry, through a detail to the board of experts from that bureau.

Important progress has been made in the research work which involves in general the following investigations: (1) That of developing successful methods of soil sterilization by heat, chemicals, or other means, all of which are being tested singly and in combination; (2) the testing of both American and imported varieties of potatoes for reaction to the disease and adaptability to the climates and soils of the infested and adjacent regions, together with studies on the permanence of immunity; (3) the study of the character of immunity in inheritance and the production by breeding of new immune varieties better adapted to these regions; (4) determination of the effect of climate and soil conditions upon the distribution and development of the disease; and (5) a painstaking study of the life history of the organism.

Very important results have been obtained from these studies, notably the immunity to the disease determined for certain important classes of potatoes and the possibilities of local control by limiting plantings to such immune varieties and by direct corrective work. This outcome has largely eliminated the fear that the wart disease might follow the same destructive course in this country that it has in portions of Europe. The continued necessity for thoroughgoing survey work and for the strictest administration of local quarantine regulations is none the less existent, as well as the research work which may ultimately develop means for the eradication of the disease.

The regulations governing the importation of potatoes into the United States were revised and reissued February 16, 1921, effective March 1, 1921. Only minor changes were made in this revision, which was more particularly to incorporate three amendments which have been promulgated since the issuance of the original regulations under the order restricting the entry of potatoes from certain countries.

UNITED STATES QUARANTINED TO PROTECT HAWAII FROM ENTRY OF PESTS.

A quarantine restricting the movement from the United States into Hawaii of sugar cane, corn (other than shelled corn), cotton and alfalfa plants, and fruits of the avocado and papaya in the natural or raw state, was issued at the earnest request of the Hawaiian authori-

ties. This quarantine is designed to guard against the entry into Hawaii of the articles named merely as passengers' baggage, or as ships' stores. Commercial importations are safeguarded under Territorial laws, and mail shipments by terminal inspection recently inaugurated.

Under this quarantine, regulations have been issued providing for inspection at the ports of Hawaii, with respect to ships or vessels from the United States, of ships' stores and the baggage and effects of passengers or crews for the purpose of ascertaining whether any of the fruits, vegetables, or other articles covered by the foregoing quarantine are contained in such ships or vessels or whether there remains any infestation from such fruits, vegetables, or other articles. The regulations also provide for necessary disinfection and the posting of warning notices.

COTTON, COTTON WASTE, COTTON BAGGING, AND COTTONSEED PRODUCTS IMPORTATIONS.

There was a decided reduction in the importations of cotton during the year. The total number of bales entered was 221,303, which is less than half the number entered during the fiscal year 1919-20, namely, 595,765. However, the importations exceed those of the fiscal years 1916-17, 1917-18, and 1918-19.

With respect to cotton waste, it is interesting to note that while the importations of cotton decreased the waste entered exceeded last year's importations by 20,000 bales and was only about 4,500 bales less than the maximum number entered in any preceding year. The total importations of waste amounted to 36,876 bales.

The importations of bagging show a decided decrease, viz., 74,076 bales, as against 163,383 bales in 1919-20. The importations of 1920-21 exceeded, however, the importations of any fiscal year other than the one immediately preceding it.

The only foreign cotton seed now permitted to enter the United States is that originating in the Imperial Valley, Lower California, Mexico. The amount imported this year is nearly twice that of the previous year.

Cottonseed products, including cottonseed oil, are prohibited entry from Mexico, except when they originate in mills in the Laguna district. The entry of such products during the last fiscal year shows a marked decrease in the importations for the preceding year, indicating the growth of demand for home consumption.

The following tables indicate, respectively, the importations of cotton, cotton waste, bagging, cotton seed, and cottonseed products during the fiscal year.

Ginned cotton, by ports of entry and country of origin, 1920-21.

(Bales.)

Country.	Boston.	Calexico.	New Orleans.	New York.	San Francisco.	St. Albans.	Total.
Brazil.....				9			9
British West Indies.....				57			57
China.....	2,106			10,476	435		13,017
Colombia.....				10			10
Dutch East Indies.....				788			788
Egypt.....	57,265			9,788			67,053
Haiti.....				4,531			4,531
India.....	1,342			7,158			8,700
Mexico.....		88,047		300			88,347
Nicaragua.....				1			1
Peru.....	488			31,698	4		32,190
Porto Rico.....				1,247			1,247
Santo Domingo.....				301			301
Turkey.....				4			4
United States (continental).....	802		105	2,501		1,442	4,850
Venezuela.....				141			141
(Origin unknown).....				57			57
Total.....	62,203	1 88,047	105	69,067	439	1,442	221,303

¹ Includes 11,457 bales unginned cotton from Imperial Valley, Lower California, Mexico.*Cotton waste, by country of origin and port of entry, 1920-21.*

(Bales.)

Country.	Bos- ton.	De- troit.	Gal- veston.	New Or- leans.	New York.	Phi- la- del- phia.	Port- land.	Rich- mond.	San Fran- cisco.	Sav- an- nah.	Seat- tle.	Total.	
Belgium.....	40				78								118
Canada.....	525				41	1,900							2,534
China.....	160			2,173									2,853
England.....	983		200		2,190	4,787		320	68				8,360
France.....					8,175			70					8,245
Germany.....					741			126					867
Holland.....					897		1,270						2,167
India.....					1,500								1,500
Italy.....	3				5,141	69							5,213
Japan.....	368				3,138			100		5			3,613
Scotland.....					461								461
Switzerland.....					238								268
United States.....	302	40		9	59	267							677
Total.....	2,381	40	200	9	24,862	8,489	420	68	5	200	202		36,876

Bagging, by country of origin and port of entry, 1920-21.

(Bales.)

Country.	Balti- more.	Boston.	New Orleans.	New York.	Norfolk.	Philadel- phia.	Port Huron.	Total.	
Algeria.....					107				107
Belgium.....	481	4,529	2,874	6,290		1,201			15,375
Canada.....		1,285	385	113			1,452		3,236
Denmark.....				868					868
Egypt.....				48					48
England.....	1,905	12,411	4,798	4,249	390	5,695			29,448
France.....			566	8,409		1,263			10,238
Germany.....		350		465		131			956
Holland.....	516	943	773	3,487	165	2,055			7,939
Italy.....		697		2,909					3,606
Panama.....				17					17
Scotland.....		575		119					694
Spain.....				1,205					1,205
Switzerland.....				339					339
Total.....	2,902	20,790	9,397	28,625	555	10,355	1,452		74,076

Cotton seed and cottonseed products, 1920-21.

Port.	Cotton seed.	Cotton-seed cake.	Cotton-seed meal.
Calexico.....	Tons. 41,904	Tons. 4,524	Tons.
Eagle Pass.....		130	.....
Laredo.....			457
New York.....		458	
Portland.....			555
San Francisco.....		4,581	
Total.....	41,904	9,703	1,012

NURSERY STOCK, PLANT AND SEED QUARANTINE.

Quarantine No. 37, restricting the entry of foreign plants and plant products for propagation, has been in force for two years. Some minor amendments have been made to this quarantine from time to time. As a result of the practical working out of the quarantine during this period, it became desirable to make a considerable number of changes in the regulations. These, together with the earlier amendments, are embodied in a revision of the regulations effective on and after August 1, 1921.

The important changes are in Regulations 2 and 7. The requirement is now made with respect to importations under Regulation 2 that they shall be free from sand, soil, or earth. This was necessitated from the occasional importation of food products with earth, as, for example, roots of horseradish. Under Regulation 7 inspection must now be made at the time of packing of all nursery stock and other plants and seeds and the certificate of inspection must include also certification of packing materials and that the plants have been washed and are free from soil.

In addition to the unlimited commercial entry of certain classes of plants which is permitted under Quarantine No. 37, it is perhaps now generally understood that provision is also made under Regulation 14 of this quarantine for the importation of all other plants whatsoever in quantities sufficient to meet any legitimate introduction needs. In other words, for the purpose of keeping the country supplied with any new variety or any necessary propagating stock. For such purposes 622 permits have been issued during the year and importations have already been made under 429 of these permits. The nature and amount of these importations are indicated in the following table:

Special permit importations for the year 1920-21.

Class of plants.	Permits issued.		Permits imported.	
	Number.	Quantity.	Number.	Quantity.
Gladioli.....	207	6,119,968	146	3,309,375
Iris.....	95	5,937,413	65	4,035,247
Peonies.....	72	120,815	37	14,060
Other bulbs, rhizomes, and roots.....	51	1,056,117	34	474,466
Ornamentals.....	69	545,650	28	163,888
Roses.....	50	38,787	35	34,774
Orchids.....	62	16,851	45	7,723
Herbaceous plants.....	45	123,454	27	90,337
Fruit trees.....	6	563	2	114
Dahlias.....	55	5,395	41	2,650
Total.....		13,965,013		8,132,634

The three tables following record the importations of nursery stock and other plants and seeds, of which unlimited commercial importation under Regulation 3 is provided for in the quarantine, namely, (1) importations of fruit and rose stocks; (2) importations of bulbs; and (3) importations of tree seeds.

Country of origin and nature of importations under regulation 3, Quarantine 37.

FRUIT AND ROSE STOCKS.

(Figures indicate number of plants.)

Country of origin.	Fruit stocks.						Rose stocks.	Totals by countries.
	Apple.	Cherry.	Pear.	Plum.	Quince.	All other fruits.		
Austria.....		1,018						1,018
Czechoslovakia.....	150	.....	50	.....		3	.....	203
Costa Rica.....						200	.....	200
England.....	100						1,181,160	1,181,200
France.....	4,396,450	8,093,698	3,214,104	2,000,375	1,633,250	344,890	2,176,282	21,172,049
Holland.....	584,100	884,648	469,070	285,133	29,000	25,000	2,264,019	4,540,961
Ireland.....							269,800	269,800
Italy.....				103,000		35,399	.....	138,399
Japan.....			3,000				.....	3,000
Mexico.....						1,500	.....	1,500
Scotland.....							43,000	43,000
Total.....	4,980,800	8,889,364	3,686,224	2,388,508	1,065,250	406,902	5,934,192	27,351,240

BULBS.
(Figures indicate number of bulbs.)

Country of origin.	Crocus.	Hyacinth.	Lily.	Lily of the valley.	Narcissus.	Tulip.	Unclassified.	Totals by countries.
Azores.....				30,000				30,000
Bermuda.....		102,986						102,986
Canary Islands.....		6,172						6,172
China.....					4,343,136			4,343,136
England.....		50	3,282		1,079,069	200		1,082,601
France.....	10,500	3,609,666	193,283		40,996,054	259,910		45,039,413
Germany.....		15,803,175	856,850					16,660,025
Holland.....	5,504,305	18,959,175	75,969	2,749,896	31,557,816	54,815,233	1,415,360	115,077,763
Ireland.....						1,000		1,000
Italy.....							3,341,000	3,341,000
Japan.....		6,275,666			9,120			6,281,786
Total.....	5,514,805	22,568,891	22,490,533	3,606,746	77,956,195	55,075,343	4,756,369	191,968,882

TREE SEEDS.
(Figures indicate pounds.)

Country of origin.	Apple.	Cherry.	Nuts.	Orna-mental and tree.	Palm.	Pear.	Plum.	All other fruit seeds.	Totals by countries.
Australia.....				5	189,920			900	189,925
Austria.....				1,599					2,499
Brazil.....					2,438				2,438
British Guiana.....					100				100
Canada.....			35						35
Costa Rica.....					75				75
Cuba.....					1,000				1,000
China.....					150				150
England.....					15,000				15,000
France.....	20,728	362	107	2,293	310	546	8,118	68	32,532
Germany.....	2,025	75		1,200		120	394		3,814
Holland.....	3,000			1		25	360	1	3,387
India.....					1,178				1,178
Italy.....					1,436				2,147
Japan.....		1	282	1,277		8,574	94	379	10,607
Total.....	25,753	438	389	9,024	208,993	9,265	10,577	448	264,887

IMPORTATIONS OF OTHER RESTRICTED PLANT PRODUCTS.

In addition to the foregoing record of importations of plants and plant products for propagation, the board has supervised the importation, under quarantine, of 154,635 sacks of potatoes, chiefly from Denmark; upward of 20,000 crates of oranges, chiefly from Japan; 1,142 bags of wheat from Japan and Australia; and 29,634 bags of corn, originating in Manchuria.

The board has also supervised and safeguarded the importation for immediate exportation in bond to other countries of considerable quantities of prohibited or restricted plants and plant products.

The enforcement of Quarantine No. 49, on account of the black fly, as elsewhere noted (p. 8), has brought under restriction and regulation practically all fruit and vegetable importations from Cuba, the Bahamas, Jamaica, Canal Zone, Costa Rica, India, Philippine Islands, Ceylon, and Java. This quarantine has been in operation since April 1, and the available records of the importations represent only a fraction of the year, and the tabulation of them has therefore been omitted in this report.

INSPECTION OF IMPORTED PLANTS AND PLANT PRODUCTS.

The records of this board indicate that during the fiscal year 324 recognized species and 134 insects identified to the genus only, brought in with importations of plants, were intercepted by State and Federal inspectors. In spite of the reduction in the number of miscellaneous plants entering the United States, the records show that there were more insects intercepted during the fiscal year under review than has been the case any year since 1912. This has resulted from the operation of Quarantine No. 37, which brings all importations of ornamentals under special permit with inspection at Washington as a condition of entry by the highly trained and efficient inspection personnel of the board, and in part also by greater laxity in the foreign inspection and certification service. The latter condition has led to strong representations and warnings being sent to the proper officials of the various foreign countries at fault, and an improvement in the condition of materials offered for import hereafter is anticipated.

In the early spring of 1921 French fruit seedlings began arriving infested with nests of the brown-tail moth, and as soon as this condition was noted the various State and Federal inspectors were urged to give all such shipments very careful examination. As a result of this inspection, 182 brown-tail nests were found in 41 French shipments, in contrast with 63 infested French shipments which have arrived during the last nine years. A single nest of the brown-tail moth was also intercepted on fruit seedlings from Holland, and nests of the white tree pierid were reported on 20 French shipments of fruit seedlings.

Other interceptions of interest include: The sweet-potato weevil from the Bahama Islands and Jamaica, and two injurious weevils infesting yams from Jamaica; the avocado stenoma from the Canal Zone, Costa Rica, and Spanish Honduras; an avocado weevil, *Conotrachelus perseae*, from Mexico, and also an unrecognized species of *Heilipus* in avocados from Mexico; the West Indian fruit fly from Cuba, Mexico, and Jamaica; the citrus black fly from Cuba, British

West Indies, and Jamaica; the Mexican fruit fly from Mexico; the sorrel cutworm from France; the lesser bulb fly from Holland and France; the sugar-cane borer, *Metamasius sericeus* Oliv., in shipments of bananas from Cuba, Costa Rica, Spanish Honduras, and Guatemala; the pink bollworm from Mexico, Egypt, India, England, and Holland; the European corn borer in broom corn from Italy; the cotton-boll weevil from Costa Rica; the dictyosperm scale, *Chrysomphalus dictyospermi*, from British Honduras, Bahama Islands, Dominica, France, Bermuda, Jamaica, Cuba, Nicaragua, Spanish Honduras, and Costa Rica; what appears to be an injurious potato weevil, probably *Trypopremnon latithorax*, in Irish potatoes from Mexico, and 82 recognized species of scale insects from various parts of the world.

A long list of plant diseases have also been intercepted during the year in connection with imported plants and plant products. These include important diseases of citrus and other fruits, potato, sugar cane, bamboo, azalea, rhododendron, and other ornamentals. Important among these are several interceptions of citrus canker, a sugar-cane disease new to the United States, and a new potato disease, which has hitherto been known only in England and Scotland. A good many of the other diseases intercepted were either new or not now widely spread in the United States.

INSPECTION OF THE PLANT INTRODUCTION GARDENS.

As in the past, the inspectors of this board have continued to examine the various plant-introduction gardens maintained by the Department of Agriculture at Yarrow and Bell, Md., Miami and Brooksville, Fla., Savannah, Ga., and Chico, Calif., and the field station of the Office of Dry Land Agriculture at Mandan, N. Dak.

PORt-INSPECTION SERVICE.

The port-inspection service is the direct means of enforcing the various foreign quarantine and restrictive orders and of regulating and safeguarding the entry of products under restriction, and is necessarily a continuing and growing service, as a result of the promulgation from time to time of new quarantine and restrictive orders. The work at minor ports of entry where the volume of imports is not sufficient to warrant a resident inspector is taken care of by a detail of inspectors from time to time. Maintenance of a regular office at the port of Norfolk, Va., has been discontinued, inasmuch as restricted products are rarely offered for entry at that port, and an office has been opened at Baltimore, Md.

An important part of this work is the inspection of vessels for contraband material, not only as cargo, but also in passengers' baggage, ships' stores, or crews' effects. The number of vessels by ports of entry thus inspected during the year is as follows: Boston, 764; Philadelphia, 889; Baltimore, 254; Norfolk, 1,203; New Orleans, 2,135; Seattle, 128; and Portland, 90; a total of 5,463 vessels. At New York the inspection service is not adequate to make an examination of all the vessels entering that port, but occasional examinations are made of passengers' baggage, ships' stores, and the quarters and effects of crews. The bulk of the work at that port is the examination and safeguarding of commercial importations. It undoubt-

edly would be highly desirable to have the service so strengthened that the vessel inspection could be made as complete at New York as it now is at most of the other ports. Naturally the risk from importations is much greater, however, at ports which have more direct connection with interior cultural conditions than has New York.

In all, 1,119 lots of contraband materials were intercepted as follows: Plants, 536; sugar cane, 132; sweet potatoes, 159; citrus fruits, 154; cotton, 19; corn, 24; avocados, 79; mangos, 15; and paddy rice, 1. These interceptions indicate plainly the need for this service.

As in former years, the State plant quarantine inspectors of California, Florida, and Mississippi have been carried as collaborators of this board, and very valuable aid has thus been rendered to the Federal service. The efficiency developed at the various ports of entry is also in a large measure due to the hearty cooperation and assistance given by the customs officials.

TERMINAL INSPECTION OF INTERSTATE MAIL SHIPMENTS OF PLANTS AND PLANT PRODUCTS.

Terminal inspection of mail shipments of plants and plant products, authorized by the act of March 4, 1915, is conducted entirely at the expense of the States concerned. During the year the State of Mississippi, the District of Columbia, and the Territory of Hawaii instituted such inspection. The States of California, Arizona, Montana, Oregon, Washington, and Arkansas had previously, in the order named, taken advantage of the provisions of the act referred to. Not only are numerous plant pests intercepted by this system of inspection, but also occasional shipments of plants and plant products mailed in violation of Federal or State quarantines.

NEW PLANT QUARANTINES.

The following foreign and domestic quarantines and other restrictive orders have been promulgated or revised during the year:

Domestic.—The European corn-borer quarantine (a revision), the nursery stock, plant, and seed quarantine (a revision), the Japanese-beetle quarantine (a revision), the gipsy-moth and brown-tail-moth quarantine (a revision), the pink-bollworm quarantine (a revision), the Mexican bean-beetle quarantine, and the quarantine restricting the movement from the United States into Hawaii of sugar cane, corn, cotton, alfalfa, and fruits of avocado and papaya.

Foreign.—The citrus black-fly quarantine, and the European corn-borer quarantine (a revision).

Other restrictive orders.—Regulations governing the importation of potatoes into the United States (a revision), and rules and regulations governing (1) entry for immediate export, (2) entry for immediate transportation and exportation in bond, and (3) safeguarding the arrival, at a port where entry or landing is not intended, of prohibited plants and plant products (a revision).

CONVICTIONS FOR VIOLATIONS OF THE PLANT QUARANTINE ACT.

The solicitor of the department reported, during the past year, the conviction of 11 shippers for violations of the plant quarantine act, 1 in regard to the Mediterranean fruit fly and the melon-fly quarantine, 4 in regard to the gipsy-moth and brown-tail-moth quarantine, and 6 in regard to the white-pine blister-rust quarantine. Fines aggregating \$262 were imposed.

LIST OF CURRENT QUARANTINE AND OTHER RESTRICTIVE ORDERS.

QUARANTINE ORDERS.

The numbers assigned to these quarantines indicate merely the chronological order of issuance of both domestic and foreign quarantines in one numerical series. The quarantine numbers missing in this list are quarantines which have either been superseded or revoked. For convenience of reference these quarantines are here classified as domestic and foreign. The record includes quarantines up to October 1, 1921.

DOMESTIC QUARANTINES.

Date palms.—Quarantine No. 6: Regulates the interstate movement of date palms or date-palm offshoots from Riverside County, Calif., east of the San Bernardino meridian; Imperial County, Calif.; Yuma, Maricopa, and Pinal Counties, Ariz.; and Webb County, Tex.; on account of the *Parlatoria* scale (*Parlatoria blanchardi*) and the *Phoenicococcus* scale (*Phoenicococcus marlatti*).

Hawaiian fruits.—Quarantine No. 13, revised: Prohibits or regulates the importation from Hawaii of all fruits and vegetables, in the natural or raw state, on account of the Mediterranean fruit fly and the melon fly.

Sugar cane.—Quarantine No. 16: Prohibits the importation from Hawaii and Porto Rico of living canes of sugar cane, or cuttings or parts thereof, on account of certain injurious insects and fungous diseases.

Five-leaved pines, Ribes and Grossularia.—Quarantine No. 26, as amended: Prohibits the interstate movement of five-leaved pines, currant and gooseberry plants from all States east of and including the States of Minnesota, Iowa, Missouri, Arkansas, and Louisiana to points outside of this area; prohibits, further, (1) the interstate movement of five-leaved pines and black-currant plants to points outside the area comprising the States of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, and New York, and (2) to protect the State of New York, the movement from the New England States, on account of the white-pine blister rust.

Sweet potato and yam.—Quarantine No. 30: Prohibits the movement from the Territories of Hawaii and Porto Rico into or through any other Territory, State, or District of the United States of all varieties of sweet potatoes and yams (*Ipomoea batatas* and *Dioscorea* spp.), regardless of the use for which the same are intended, on account of the sweet-potato weevil (*Cylas formicarius*) and the sweet-potato scarabee (*Euscepes batatae*).

Banana plants.—Quarantine No. 32: Prohibits the movement from the Territories of Hawaii and Porto Rico into or through any other Territory, State, or District of the United States of any species or variety of banana plants (*Musa* spp.), regardless of the use for which the same are intended, on account of two injurious weevils, *Rhabdocnemis obscurus* and *Metamasius hemipterus*.

Black stem rust.—Quarantine No. 38: Prohibits the movement interstate to any point outside of the quarantined area of the common barberry and its horticultural varieties, as well as certain other species of *Berberis* and *Mahonia*, on account of the black stem rust of wheat, oats, barley, rye, and many wild and cultivated grasses.

European corn borer.—Quarantine No. 43, as amended: Regulates the movement interstate to any point outside of the quarantined area of corn and broom corn (including all parts of the stalk), celery, green beans in the pod, beets with tops, spinach, rhubarb, oat and rye straw as such or when used as packing, cut flowers or entire plants of chrysanthemum, aster, cosmos, zinnia, hollyhock, and cut flowers or entire plants of gladiolus and dahlia, except the bulbs thereof, without stems, on account of the European corn borer (*Pyrausta nubilalis*).

Gipsy moth and brown-tail moth.—Quarantine No. 45, as amended: Regulates the movement interstate to any point outside of the quarantined towns and territory, or from points in the generally infested area to points in the lightly infested area, of stone or quarry products, and of the plants and the plant products listed therein. The quarantine covers all the New England States.

Hawaiian and Porto Rican cotton, cotton seed and cottonseed products.—Quarantine No. 47: Regulates the movement of cotton, cotton seed, and cottonseed products from Hawaii and Porto Rico on account of the pink bollworm and the cotton blister mite, respectively.

Japanese beetle.—Quarantine No. 48, as amended: Regulates the movement interstate to any point outside of certain portions of the counties of Burlington and Camden, N. J., and certain portions of the counties of Philadelphia and Bucks, Pa., of (1) farm, garden, and orchard products of all kinds; (2) grain and forage crops of all kinds; (3) nursery, ornamental, and greenhouse stock and all other plants, includ-

ing bulbs and cut flowers, and (4) soil, compost and manure other than fresh manure, on account of the Japanese beetle (*Popillia japonica*).

United States quarantined to protect Hawaii.—Quarantine No. 51: Regulates the movement from the United States to the Territory of Hawaii, as ships' stores or as baggage or effects of passengers or crews, of sugar cane, corn, cotton, alfalfa, and the fruits of the avocado and papaya.

Pink bollworm.—Quarantine No. 52: Prohibits the interstate movement from the infested and regulated areas of Texas, Louisiana, and New Mexico of cotton, including all parts of the plant, seed cotton, cotton lint, linters, gin waste and all other forms of cotton lint, cotton seed, cottonseed hulls, cottonseed cake and meal, bagging and other containers of the articles enumerated, and also railway cars, boats, and other vehicles which have been used in conveying cotton and cotton products grown in the infested districts or which are fouled with such products, hay and other farm products, farm household goods, and farm equipment, except as provided in the rules and regulations supplemental thereto, on account of the pink bollworm of cotton (*Pectinophora gossypiella* Saunders).

FOREIGN QUARANTINES.

Irish potatoes.—Quarantine No. 3: Prohibits the importation of the common or Irish potato from Newfoundland; the islands of St. Pierre and Miquelon; Great Britain, including England, Scotland, Wales, and Ireland; Germany; and Austria-Hungary, on account of the disease known as potato wart.

Mexican fruits.—Quarantine No. 5, as amended: Prohibits the importation of oranges, sweet limes, grapefruit, mangoes, achras sapotes, peaches, guavas, and plums from the Republic of Mexico, on account of the Mexican fruit fly.

Five-leaved pines, Ribes, and Grossularia.—Quarantine No. 7, as amended: Prohibits the importation from each and every country of Europe and Asia, and from the Dominion of Canada and Newfoundland, of all five-leaved pines and all species and varieties of the genera *Ribes* and *Grossularia*, on account of the white-pine blister rust.

Cotton seed and cottonseed hulls.—Quarantine No. 8, as amended: Prohibits the importation from any foreign locality and country, excepting only the locality of the Imperial Valley, in the State of Lower California, Mexico, of cotton seed (including seed cotton) of all species and varieties, and cottonseed hulls, on account of the pink bollworm. Cotton and cotton seed from the Imperial Valley may be entered under permit and regulation.

Seeds of avocado or alligator pear.—Quarantine No. 12: Prohibits the importation from Mexico and the countries of Central America of the seeds of the avocado or alligator pear, on account of the avocado weevil.

Sugar cane.—Quarantine No. 15: Prohibits the importation from all foreign countries of living canes of sugar cane, or cuttings or parts thereof, on account of certain injurious insects and fungous diseases. There are no restrictions on the entry of such materials into Hawaii and Porto Rico.

Citrus nursery stock.—Quarantine No. 19: Prohibits the importation from all foreign localities and countries of all citrus nursery stock, including buds, scions, and seeds, on account of the citrus canker and other dangerous citrus diseases. The term "citrus," as used in this quarantine, includes all plants belonging to the subfamily or tribe *Citrateae*.

European pines.—Quarantine No. 20: Prohibits, on account of the European pine-shoot moth (*Eucryria buoliana*), the importation from all European countries and localities of all pines not already excluded by Quarantine No. 7.

Indian corn or maize and related plants.—Quarantine No. 24, as amended: Prohibits the importation from southeastern Asia (including India, Siam, Indo-China, and China), Malayan Archipelago, Australia, New Zealand, Oceania, Philippine Islands, Formosa, Japan, and adjacent islands, in the raw or unmanufactured state, of seed and all other portions of Indian corn or maize (*Zea mays L.*), and the closely related plants including all species of Teosinte (*Euchlaena*), Job's tears (*Coix*), *Polytoca*, *Chionachne*, and *Selerachne*, on account of the downy mildews and *Physoderma* diseases of Indian corn, except that Indian corn or maize may be imported under permit and upon compliance with the conditions prescribed in the regulations of the Secretary of Agriculture.

Citrus fruit.—Quarantine No. 28: Prohibits the importation from eastern and southeastern Asia (including India, Siam, Indo-China, and China), the Malayan Archipelago, the Philippine Islands, Oceania, (except Australia, Tasmania, and New Zealand), Japan (including Formosa and other islands adjacent to Japan), and the Union of South Africa, of all species and varieties of citrus fruits, on account of the citrus canker, except that oranges of the mandarin class (including satsuma

and tangerine varieties) may be imported under permit and upon compliance with the conditions prescribed in the regulations of the Secretary of Agriculture.

Sweet potato and yam.—Quarantine No. 29: Prohibits the importation for any purpose of any variety of sweet potatoes or yams (*Ipomoea batatas* and *Dioscorea* spp.) from all foreign countries and localities, on account of the sweet-potato weevils (*Cylas* spp.) and the sweet-potato scarabee (*Euscepes batatae*).

Banana plants.—Quarantine No. 31: Prohibits the importation for any purpose of any species or variety of banana plants (*Musa* spp.), or portions thereof, from all foreign countries and localities, on account of the banana-root borer (*Cosmopolites sordidus*). No restrictions are placed on the importation of the fruit of the banana.

Bamboo.—Quarantine No. 34: Prohibits the importation for any purpose of any variety of bamboo seed, plants, or cuttings thereof capable of propagation, including all genera and species of the tribe *Bambuseae*, from all foreign countries and localities, on account of dangerous plant diseases, including the bamboo smut (*Ustilago shiraiana*). This quarantine order does not apply to bamboo timber consisting of the mature dried culms or canes which are imported for fishing rods, furniture making, or other purposes, or to any kind of article manufactured from bamboo, or to bamboo shoots cooked or otherwise preserved.

Nursery stock, plants, and seeds.—Quarantine No. 37, revised, with regulations: Prohibits the importation of nursery stock and other plants and seeds from all foreign countries and localities, on account of certain injurious insects and fungous diseases, except as provided in the regulations. Under this quarantine the following plants and plant products may be imported without restriction: Fruits, vegetables, cereals, and other plant products imported for medicinal, food, or manufacturing purposes, and field, vegetable, and flower seeds. The entry of the following plants is permitted under permit: Lily bulbs, lily of the valley, narcissus, hyacinths, tulips, and crocus; stocks, cuttings, scions, and buds of fruits; rose stocks, including manetti, multiflora, brier rose, and rosa rugosa; nuts, including palm seeds, seeds of fruit, forest, ornamental, and shade trees; seeds of deciduous and evergreen ornamental shrubs, and seeds of hardy perennial plants.

Provision is also made for the issuance of special permits under safeguards to be prescribed in such permits for the entry in limited quantities of nursery stock and other plants and seeds not covered in the preceding lists for the purpose of keeping the country supplied with new varieties and necessary propagating stock.

Flag smut and take-all.—Quarantine No. 39, with regulations: Prohibits the importation of seed or paddy rice from Australia, India, Japan, Italy, France, Germany, Belgium, Great Britain, Ireland, and Brazil on account of two dangerous plant diseases known as flag smut (*Urocystis tritici*) and take-all (*Ophiobolus graminis*). Wheat, oats, barley, and rye may be imported from the countries named only under permit and upon compliance with the conditions prescribed in the regulations of the Secretary of Agriculture.

European corn borer.—Quarantine No. 41, with regulations: Prohibits the importation of the stalk and all other parts, whether used for packing or other purposes, in the raw or unmanufactured state, of Indian corn or maize, broom corn, sweet sorghums, grain sorghums, Sudan grass, Johnson grass, sugar cane, pearl millet, napier grass, teosinte and Job's tears, from all foreign countries and localities, except as provided in the rules and regulations supplemental thereto, on account of the European corn borer (*Pyrausta nubilalis*) and other dangerous insects and plant diseases.

Mexican corn.—Quarantine No. 42, with regulations: Prohibits the importation of Indian corn or maize from Mexico, except as provided in the rules and regulations supplemental thereto, on account of the contamination of such corn with cotton seed more or less infested with the pink bollworm.

Stocks, cuttings, scions, and buds of fruits.—Quarantine No. 44: Prohibits the importation of stocks, cuttings, scions, and buds of fruits from Asia, Japan, Philippine Islands, and Oceania (including Australia and New Zealand) on account of dangerous plant diseases, including Japanese apple cankers, blister blight, and rusts, and injurious insect pests, including the oriental fruit moth, the pear fruit borer, the apple moth, etc.

Citrus black fly.—Quarantine No. 49, with regulations: Prohibits the importation of fruits and vegetables, and of plants or portions of plants used as packing material in connection with shipments of such fruits and vegetables, or otherwise, from Cuba, the Bahamas, Jamaica, Canal Zone, Costa Rica, India, Philippine Islands, Ceylon, and Java, except as provided in the rules and regulations supplemental thereto, on account of the citrus black fly (*Alurocanthus woglumi*).

OTHER RESTRICTIVE ORDERS.

The regulation of the entry of nursery stock from foreign countries into the United States was specifically provided for in the plant-quarantine act. The act further provides for the similar regulation of any other class of plants or plant products when the need therefor shall be determined. The entry of the plants and plant products listed below has been brought under such regulation:

Nursery stock.—The conditions governing the entry of nursery stock and other plants and seeds from all foreign countries and localities are indicated above under "Foreign Quarantines." (See Quarantine No. 37.)

Irish potatoes.—The importation of Irish potatoes is prohibited altogether from the countries enumerated in the potato quarantine. Potatoes may be admitted from other foreign countries under permit and in accordance with the provisions of the regulations issued under the order of December 22, 1913, bringing the entry of potatoes under restriction on account of injurious potato diseases and insect pests. Importation of potatoes is now authorized from the following countries: Denmark, Cuba, Bermuda, and the Dominion of Canada. The regulations issued under this order have been amended so as to permit, free of any restrictions whatsoever under the plant-quarantine act, the importation of potatoes from any foreign country into the Territories of Porto Rico and Hawaii for local use only and from the Dominion of Canada and Bermuda into the United States or any of its Territories or Districts.

Avocado, or alligator pear.—The order of February 27, 1914, prohibits the importation from Mexico and the countries of Central America of the fruits of the avocado, or alligator pear, except under permit and in accordance with the other provisions of the regulations issued under said order, on account of the avocado weevil. Entry is permitted through the port of New York only and is limited to the large, thick-skinned variety of the avocado. The importation of the small, purple, thin-skinned variety of the fruit of the avocado and of avocado nursery stock under 18 months of age, is prohibited.

Cotton.—The order of April 27, 1915, prohibits the importation of cotton from all foreign countries and localities, except under permit and in accordance with the other provisions of the regulations issued under said order, on account of injurious insects, including the pink bollworm. These regulations apply in part to cotton grown in and imported from the Imperial Valley, in the State of Lower California, in Mexico.

Corn.—The order of March 1, 1917 (Amendment No. 1, with regulations to Notice of Quarantine No. 24), prohibits the importation of Indian corn or maize in the raw or unmanufactured state from the countries and localities listed in Notice of Quarantine No. 24, except under permit and in accordance with the other provisions of the regulations issued under said order, on account of injurious diseases of Indian corn.

Cottonseed products.—The order of June 23, 1917, prohibits the importation of cottonseed cake, meal, and all other cottonseed products, except oil, from all foreign countries, and a second order of June 23, 1917, prohibits the importation of cottonseed oil from Mexico, except under permit and in accordance with the other provisions of the regulations issued under said orders, on account of injurious insects, including the pink bollworm.

Citrus fruits.—The order of June 27, 1917 (Notice of Quarantine No. 28, with regulations), prohibits the importation from the countries and localities listed therein of all species and varieties of citrus fruits, excepting only oranges of the mandarin class (including satsuma and tangerine varieties), on account of the citrus-canker disease. Oranges of the mandarin class (including satsuma and tangerine varieties) may be imported under permit and in accordance with the other provisions of the regulations issued under said order.

Indian corn, broom corn, and related plants.—The order of February 21, 1920 (Notice of Quarantine No. 41, with regulations), prohibits the importation in the raw or unmanufactured state of the stalk and all other parts of Indian corn or maize, broom corn, sweet sorghums, grain sorghums, Sudan grass, Johnson grass, sugar cane, including Japanese varieties, pearl millet, napier grass, teosinte, and Job's tears from all foreign countries and localities on account of the European corn borer and other dangerous insects and plant diseases. The regulations issued under said order permit the importation without restriction of sorghum hay from Canada and clean shelled or threshed grain, from any country, of the plants covered by this order. Provision is also made for the importation of broom corn under permit and in accordance with the other provisions of the regulations for manufacturing purposes.

Mexican corn.—The order of February 21, 1920 (Notice of Quarantine No. 42, with regulations), prohibits the importation of Indian corn or maize from Mexico, except under permit and in accordance with the other provisions of the regulations issued

under said order, on account of contamination of such corn with cotton seed more or less infested with the pink bollworm.

Stocks, cuttings, scions, and buds of fruits.—The order of March 24, 1920 (Notice of Quarantine No. 44), prohibits the importation of stocks, cuttings, scions, and buds of fruits for or capable of propagation from Asia, Japan, Philippine Islands, and Oceania (including Australia and New Zealand) on account of certain dangerous plant diseases and injurious insect pests. Provision is made for the importation under special permits issued by the Secretary of Agriculture of limited quantities of stocks, cuttings, scions, and buds of fruits from the countries and localities named for the purpose of keeping the country supplied with new varieties and necessary propagating stock.



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REPORT OF THE FORESTER.

UNITED STATES DEPARTMENT OF AGRICULTURE,
FOREST SERVICE,
Washington, D. C., October 6, 1921.

SIR: I have the honor to transmit herewith a report of the work in the Forest Service for the fiscal year ended June 30, 1921.

Respectfully,

WILLIAM B. GREELEY,
Forester.

Hon. HENRY C. WALLACE,
Secretary of Agriculture.

NATIONAL FORESTRY POLICY.

During the fiscal year 1920 the Forest Service was largely instrumental in bringing before the people of the United States our present serious situation as to timber supply. Its outstanding points are the disappearance of three-fifths of the virgin forests of this country, a present drain upon our remaining forests over four times their yearly production of wood, and the accumulation of enormous areas of denuded and idle forest land. The past year has been notable for general discussion of the forest situation, in both its national and local aspects, and the consideration of remedies. To a considerable degree this discussion has centered around two proposed measures of Federal legislation. The first of these, known as the Snell bill (H. R. 129), contemplates, among other things, an extension of public control over private forest lands under the police powers of the several States, with the Federal Government functioning as a cooperating and standardizing agency. The second measure, known as the Capper bill (S. 1345), proposes the exercise of direct Federal control over private forest lands through the medium of taxation on forest products. The two measures agree in promoting organized protection from fire over all classes of forest land in the United States, by State agencies, with financial and technical cooperation from the central Government.

The year has been equally noteworthy in the advances made in forestry legislation and constitutional provisions by a number of States. Among these may be cited the clause in the constitution recently adopted by Louisiana which empowers and directs the State legislature to enact such laws as may be necessary to conserve

the forests and other natural resources of the State and to prevent their wasteful use. The exercise of State police power over private forest lands has been strikingly asserted by laws of Louisiana and New Hampshire which require lumber operators on pine lands to leave and protect at least one seed-bearing tree per acre. The legislation dealing with the disposal of slashings in lumbering operations, as an essential phase of reforestation, has been strengthened in Massachusetts through a new law which authorizes the commissioner of conservation to require the complete removal of slashings on a strip 40 feet in width along all highways and railroads, around sawmills and logging camps, adjoining the boundaries of property holdings, and around the edges of each season's logging operation. A number of other States have also strengthened or extended the authority of their forest agencies in connection with the disposal of slashings, whose presence on logged-off lands is one of the most serious causes of destructive forest fires and lack of reforestation.

Following the survey of the remaining timber supplies in the United States and their rate of depletion, which was set forth in the report on Senate resolution 311, the Forest Service has initiated this year a second important step toward the restoration of America's forests. This is a comprehensive study of the requirements in protection and reforestation necessary to keep forest lands productive in each important region of the United States. This study has been undertaken in cooperation with State foresters, timberland owners, representatives of forest industry organizations, and forest schools. Its purpose is to put in concrete terms just what "forestry regulations" mean, in the southern pine belt, the Appalachian hardwoods, or the Lake States. Instead of dealing in general terms, it will bring the forestry movement down to specific things which are to be done in the woods, as minimum standards. It will thus serve as the basis for any plan of public regulation of forest lands and also aid the landowner who undertakes the growing of timber crops on his own initiative.

It is increasingly evident that, whatever legislation may be enacted and whatever governmental agencies may be invoked, two principles must be recognized in putting the United States upon a self-sustaining basis in timber products. They express the unavoidable logic of the situation from its public and private aspects. The first is that, because of the long-term nature of timber crops and the foresight necessary to meet future national needs, the public has an interest in forest lands not common to most forms of private property and more comparable to its interest in the operation of recognized public utilities. This public interest must be satisfied in the manner of handling forest lands. The second principle is that the production of timber is an economic process, governed by economic laws. Hence, the requirements imposed upon forest owners by the public must be equitable and practicable from a business standpoint, or must be accompanied by compensating features which make compliance a reasonable undertaking for the owner of the property.

The State or the Nation may rightfully insist that forest lands be productive rather than idle; but in so doing it can not avoid its own responsibility for reducing the general risks and losses attendant upon timber production, which have often made it a hazardous or unprofitable undertaking. The two outstanding respects in which public cooperation with the land owner is necessary, as a corollary to

regulating the use of his property, are organized protection against forest fires and the adjustment of taxes on timber lands so as to encourage their employment for growing successive crops.

The final working out of this important problem will take much time and probably will not be accomplished under any single piece of Federal legislation. Our effort, nationally and locally, must develop step by step. The subjects for Federal legislation now most urgent are:

(1) The extension of Federal cooperation in the protection of all classes of forest land from fire, in conformity with standards fixed by the Secretary of Agriculture. Such cooperation should not be limited to the watersheds of navigable streams, as at present, but should be available on all forest lands within the States prepared to join in cooperative effort.

(2) The extension of public forest ownership by incorporating within National Forests the public lands now under Federal ownership or control which are adapted primarily to growing timber or the protection of watersheds; by acquiring cut-over forest lands within or adjoining National Forests, through exchanges; and by purchasing forest lands with a view both to the protection of navigable watersheds and to the restoration of forests on areas now denuded and idle.

FORESTRY IN ALASKA.

There is much current discussion of the administration of public affairs in Alaska. In considering ways and means for bettering conditions in the Territory, it is important that we do not lose sight of the bearing of her resources upon the national timber supply. The National Forests of Alaska contain 20,000,000 acres and over 75,000,000,000 feet of timber of a quality suitable for general consumption. This is equivalent to nearly 6 per cent of all the timber in the continental United States. It includes 100,000,000 cords of pulpwood, whose serviceability for the manufacture of paper is fully established by existing commercial practice.

Except where partially covered by National Forests, all of the other timbered regions of this country have been or are now being exploited in the unrestrained interest of immediate commercial profit. While in the main a necessary economic process, this form of exploitation has largely wrecked the productive power of our forest resources. To-day the country is paying the piper. And under the pressure now felt, the public must step in and seek, by one means or another, to gather up the remnants and by slow and costly effort restore the productive forests which our feverish and short-sighted exploitation has destroyed.

For the first time in our history we have an opportunity, in Alaska, to guide the development of an immense forest region from the standpoint of permanent national interest. This does not mean putting the forests of Alaska under lock and key. It means the expansion of her forest industries as rapidly as there is a market for their products, but within the limits and under the control necessary to keep the land productive and make the supply of raw material for manufacture into lumber and paper perpetual. Wisely handled, a paper industry can be developed in Alaska as permanent as the paper industries of Scandinavia, and capable of supplying a

third of the present paper consumption of the United States. This is an opportunity which should not be thrown away by inviting unrestrained and destructive exploitation. Alaska 30 or 40 years hence should be a second Norway, with permanent mills supported by an assured supply of timber and with stable industrial communities, not as the Lake State pineries of to-day, with millions of acres of idle forest land strewn with abandoned mills and dead or dying mill towns.

There has been much loose and ignorant criticism of the National Forests of Alaska as imposing bars and locks upon the development of her timber resources. Since these National Forests were placed under administration in 1906 they have been open freely for the use of timber and other commercial resources under regulations of an exceedingly liberal and simple character. They are being cut to-day to the extent of about 45,000,000 board feet of timber annually. They furnish 86 per cent of all the timber used in the Territory. They supply every sawmill on the Alaskan coast with its logs. They furnish a large proportion of the piling, lumber, and box shooks used in Alaska's fish industry. They supply the great bulk of the timber used in the mines in their portion of the Territory. Sites have been readily and freely obtained within them for a large number of salmon canneries, other fish industries, sawmills, villages, fox farms, and commercial establishments of every character adapted to this region.

The Forest Service has labored steadily to promote the establishment of a paper industry in Alaska, which promises to be one of its most important industrial developments. The governing factors in the success of this effort have been and always will be the market and transportation conditions controlling Alaskan products. The terms offered by the Forest Service to paper manufacturers in Alaska are, indeed, more flexible and more favorable to the operator than in the case of any public timberlands in Canada, with which comparisons have frequently been drawn. By allocation of timbered areas to manufacturing sites, the paper maker in Alaska is assured of a perpetual supply of raw material for his industry, with an initial contract and reservation which may cover as much as 45 years' supply for the plant proposed. Payment for this timber is required only as it is cut; and while price adjustments at five-year intervals are provided for, they are limited in all cases to the current market value of such material in the Territory. An extended program of timber and water-power reconnaissance to obtain the essential information needed by prospective manufacturers is in progress. Two sales of pulp timber, aggregating 700,000,000 feet, have been made, and there are many pending applications and inquiries from responsible sources. The actual development of a paper industry in Alaska rests upon the general financial conditions in the United States, the paper market, and transportation facilities in Alaskan waters. Just as rapidly as bona fide undertakings for the building up of forest industries in the Territory take form, they are receiving and will receive every form of encouragement from the Forest Service consistent with the public interest in maintaining permanent production from Alaska's forests.

The primary needs of Alaska are transportation, particularly adequate marine transportation, and a decentralized administration of

public resources and affairs in the Territory itself. The evils of red tape and delay are inevitable if administrative jurisdiction is retained in Washington over matters which should be dispatched by resident officials in Alaska. The National Forests of Alaska have always been administered in all respects, except the more important transactions and questions of policy by supervisors and rangers in the Territory. In recognition of the need for the fullest decentralization, however, a separate National Forest district covering the Territory was created on January 1, 1921, under the direction of a resident district forester. Ninety-five per cent of the business on these National Forests does not pass beyond Alaska, with the exception of matters involving land titles where existing law requires reference to Washington.

A further step is desirable. There is need for correlating closely the local administrative activities of the Forest Service with those of other Federal agencies in Alaska and of the Territorial Government for settling currently any questions of overlapping jurisdiction and for securing coordinated action as new developments involving different agencies present themselves. This can be accomplished readily by organizing the chief local administrative officers of the Federal Government, together with the governor, into an Alaskan council. The existence of such a body could not fail to facilitate the efforts of the Forest Service to make the National Forests in Alaska as beneficial as possible to the people of the Territory.

At the same time the administration of these Forests must also take cognizance of the fact that Alaska is part of the United States. Her forest resources are part of our national forest resources, just as her agricultural problems are related to our national agricultural development and her fish are part of our national food supply. This means, on the one hand, that the Territory is entitled to receive the benefits of Federal appropriations and the services of Federal organizations designed to further the public welfare of the whole country, and, on the other hand, that the same national policies should be applied in Alaska as elsewhere. There is no more reason why a separate and different system should be set up for dealing with the public forests of Alaska than there is for setting up such a system in each State. Alaska needs the application to her forest problems of the experience, technical knowledge, and organization provided by the Forest Service; while the policy followed should be at one with that of the entire country, of which Alaska is simply a part.

THE PERSONNEL OF THE FOREST SERVICE.

The diversified and widely distributed work of the Forest Service and the large proportion of its employees in whom specialized training, initiative, and ability to accept responsibility are essential qualifications make the aggregate efficiency of its personnel a matter of the utmost concern. No problem outweighs in importance that of preventing retrogression or stagnation in the quality of service rendered to the Government and the public. The most critical difficulty which confronts the Forest Service to-day is that of securing and holding a personnel able in numbers and in qualifica-

tions to do efficiently the growing volume of work which we are called upon to perform.

The most immediate need is to increase the short-term protective force on the National Forests. Destructive forest fires occur because the number of guards and patrolmen which can be employed is inadequate to cover the areas needing protection. The average field officer in the four worst fire districts attempts to protect 52,000 acres. Experience demonstrates that in a normal season this protective organization is sooner or later strained beyond the breaking point, leading to serious losses of public property and emergency expenditures much greater than the cost of an organization sufficient to prevent forest fires from starting. An increase in the protective force is dictated by public economy from every standpoint.

The second outstanding need of the Forest Service is to build up its technical personnel, still depleted from the effects of wartime and subsequent conditions. For a period of four years the Service has suffered a steady loss of trained and experienced men. The rebuilding of its technical force has been blocked to a large degree by the necessity of employing every dollar on fire protection that could be made available by the large increases in wages necessarily paid to temporary employees, and by corresponding increases in the cost of equipment, supplies, and transportation. The number of technically trained forest examiners and forest assistants has dwindled from 229 in 1914 to less than 150 at the present time. The effects of this loss are painfully felt in the shortage of seasoned and qualified men to fill responsible positions in the administrative organization of the Service and to handle specialized work in its expanding activities. The force of grazing examiners and grazing assistants also falls far short of meeting the urgent needs arising in the efficient administration and improvement of the National Forest ranges.

For lack of technically trained men of adequate experience the Forest Service is now but poorly equipped to meet the growing volume of timber use on the National Forests, the imperative need of more intensive administration of range lands, and the expanding requirements of research work and cooperation with the States in fire prevention. But the worst feature of this situation is its menace for the future. There is no other training school in which men can be prepared for postions of responsibility and leadership in the Forest Service so well as in the Service itself. If the Service can not be steadily recruited in the lower ranks by able and well-trained young men, it will certainly in time begin to die at the top, and its capacity to serve the public will steadily decline. This danger is even more serious in the light of the steady growth in the use of the National Forests and in the responsibilities which the Forest Service is required to assume in relation to the entire problem of national timber supply.

The present requirements in this respect, which scarcely can be presented too strongly, are for an additional number of grazing and forest assistants who can be thrown directly into the technical administration of National Forest timber and range lands. The section of this report dealing with forest management indicates the extent

of the demand for National Forest timber now coming about in connection with the depletion of eastern forest regions and the character of technical work necessary to supply these legitimate needs while keeping up the productivity of the public timber holdings and insuring a steady supply of commercial products from them in the future. The section of the report dealing with range management brings out the importance of a similar technical and constructive development in the use of the forage crops on the National Forests. Neither of these important functions can be discharged effectively without a steady inflow of trained personnel adequate to the scope and volume of the work to be done.

As part of the same problem, I must again urge, as in the report of the preceding year, the need for relief from conditions which cause a constant drain from the organization of its experienced and efficient men, with inevitable retrogression in the efficiency of our service to the hundreds of thousands of people and the many industries which use the National Forests. The annual turnover in the various groups of scientific and technical employees still ranges from 14 to 27 per cent. The outside compensation received by these former employees of technical training exceeds, on the average, their total compensation in the Government service by 60 per cent. During the fiscal year 1920, 330 rangers, a full third of the ranger force, resigned. The Forest Service is compelled to function in no small measure as a training school for private business enterprises, taking green and inexperienced employees from the civil-service register, carrying them through a breaking-in period which is comparatively unproductive, and then losing a large proportion of them at the time when they are qualified for really effective work.

The personnel of the Forest Service will never be placed on a sound basis for making good to the Government and the public in the work expected of it until two changes are accomplished. The first is a general reclassification of grades and positions, with reasonable increases in rates of compensation and reasonable opportunities for advancement as experience and other qualifications justify. This step, of course, waits upon general legislation affecting all departments. The second step requires only a change in the form of certain appropriation items which will do away with the evils of a fixed statutory roll prescribed for classes of employees who do not belong on such a roll.

Forest supervisors, deputy forest supervisors, and forest rangers are now carried partly on a statutory roll and partly under lump-sum items. This division is illogical and discriminatory. The work of these groups of men is executive, requiring the supervision of field employees, the direction of business transactions on National Forests, and constant and responsible relations with the general public. To a large degree, it is also technical and specialized, involving the application of forestry and grazing management in the use and development of National Forest resources. The general policy of the Government has recognized the need for carrying employees of such duties and qualifications on lump-sum rolls. Thereby only can the differences developing in the efficiency of individuals, in the responsibility of their positions, and in the living costs and other factors which should be recognized in their compensation be equitably ad-

justed. The fixed statutory roll renders it impossible to recognize these differences and is primarily responsible for the excessive turnover in these grades. Furthermore, adjustments in National Forest units and in the duties and responsibilities of individual field officers are frequently possible in the interest of economy or efficiency; but such adjustments are seriously handicapped without opportunity to adjust rates of compensation to fit the new conditions or duties.

A similar situation obtains in the case of the administrative assistants on National Forests. These employees must handle routine correspondence, accounts, office records and reports, many business transactions with Forest users, the shipping and receiving of freight and supplies, the custody of public property, the hiring and dispatching of fire-fighting crews, and purchases of supplies and materials. Their positions are rated as clerical, but the job calls for an all-around business assistant. Even before the war it was impossible to obtain competent men for many of these places. In the fiscal year 1920 the Service lost 44 per cent of the employees in this capacity. During the past year the loss was 31 per cent.

By changes from statutory to lump-sum items, without increasing the amounts appropriated, this serious weakness in the National Forest personnel can in time be largely corrected. Such changes will permit holding more competent employees and adjusting duties from time to time so as to secure economy and efficiency in the handling of National Forest work which is not now possible.

NATIONAL FOREST RECEIPTS AND EXPENDITURES.

The income-producing business of the National Forests during the fiscal year 1921 resulted in receipts paid in or still due of \$4,468,940. Of this amount, \$1,964,005 due for grazing privileges had not been paid by July 1, 1921, pursuant to the special legislation for this year, which authorized the postponement of grazing fees until December 1 next.

As compared with the fiscal year 1920, the receipts show a decrease of \$324,542, or 6.7 per cent. The grazing receipts, assuming that all outstanding obligations are paid in full, will show a falling off from 1920 of less than one-half of 1 per cent. The receipts from timber sales decreased \$291,494, or 14.1 per cent. In view of the general business depression during the 12 months prior to July 1, 1921, the relatively small decrease in revenue illustrates the marked, indeed, the extraordinary, stability of the business supported by the National Forests. This fact is brought out in greater detail later in the report.

Legislation has been recommended which will authorize the crediting of deferred grazing fees, due under permits issued during the fiscal year 1921, to the receipts of that year. This is for the purpose of accomplishing the normal apportionment of the 25 per cent of gross receipts payable to the States for road and school purposes, and of the additional 10 per cent expendable by the Secretary of Agriculture on roads within the National Forests. This action is necessary to avoid serious inconvenience and possible hardship to many western counties to which the receipts from National Forests are an important source of income, and to avoid an interruption in

the construction and maintenance of National Forest roads in pursuance of the authorized appropriation for this purpose.

The following table shows the purposes for which the total appropriation for the Forest Service carried by the agricultural appropriation act was expended. The items do not include deficiency appropriations, or the appropriation for the fire protection of forested watersheds of navigable streams against fire, in cooperation with States.

Expenditure of Forest Service appropriations.

Protection and administration of the National Forests ¹ -----	\$4,943,642
Fighting fires which could not be suppressed by regular protective force ² -----	250,000
Classification, survey, and segregation of agricultural land, and accomplishment of authorized land exchanges-----	87,000
Planting of 5,505 acres of nonproducing land, maintenance of nurseries, and experiments in tree planting-----	120,640
Permanent improvements, such as buildings, bridges, trails, telephone lines, drift fences, and water improvements ³ -----	400,000
Estimating the amount and fixing the minimum value of timber for sale-----	50,000
Examination of intensively used ranges with a view of increasing their productivity by more scientific management of stock and forage-----	/
Investigations:	
Forest products, including Forest Products Laboratory at Madison, Wis.-----	\$223,260
Silvicultural-----	50,000
Range and forage plant-----	35,000
Recording, digesting, and disseminating the results of scientific technical work-----	308,260
Total -----	6,220,822

The total expenditures exceeded those during the preceding fiscal year by \$378,953, or 6.3 per cent. The increase in the expenditures for administration and protection of the National Forests, including fire suppression, was \$402,952, or more than the total increase in the amounts appropriated. In other words, other activities had to be cut down to provide for essential needs in the protection of the Forests and their use by the public.

NATIONAL FOREST PROPERTIES.

The net area of the National Forests at the close of the fiscal year was 156,666,045 acres, as against 156,032,053 acres one year before. The corresponding gross areas were 181,820,459 acres and 180,299,776 acres. The gross area includes all land within the National Forest boundaries; the net area excludes alienated lands.

The net increase of 633,992 acres includes 193,637 acres acquired by purchase under the act of March 1, 1911, and 321,360 acres in northern California added by Congress to the Modoc National Forest. Special acts of Congress authorized small additions to five other

¹ An additional emergency appropriation of \$100,000 was made available for the protection of the "blow-down" area on the Olympic National Forest, Wash. (see p. 13), of which approximately \$50,000 was expended before the fiscal year closed.

² An additional deficiency appropriation of \$775,000 was required for this purpose.

³ Of this sum nearly half is required for the maintenance of existing improvements used in the protection and administration of the National Forests.

National Forests, while by proclamation of the President small areas were added to four Forests in Arkansas, Arizona, Florida, and New Mexico. Selection by the States of other public lands outside of the National Forests caused title to many school sections to revert to the Government during the year. Nineteen presidential proclamations and Executive orders eliminating from individual National Forests 82,574 acres and an elimination of 9,498 acres due to land exchange with the State of South Dakota partially offset the increases.

The 19 minor eliminations represented the final adjustment of boundaries following the practical completion of land classification. Few exclusions from the National Forests can hereafter be made, except to the detriment of these important public properties. Changes in Forest boundaries must hereafter be in the nature of extensions which embrace all of the true forest land within a natural unit of forest production. At the close of the fiscal year 15 bills contemplating additions to National Forests were pending before the public lands committees of the Sixty-seventh Congress.

The approval by the National Forest Reservation Commission of the Alleghany Purchase Area, comprising approximately 1,000,000 acres in McKean, Forest, Elk, Warren, and Potter Counties, Pa., on the North Fork of the Alleghany River, and the extension of purchases to the Alabama, Arkansas, and Ozark National Forests have increased the total area within which purchases are authorized under the Weeks law to approximately 9,225,000 acres. Of this total, 2,535,926 acres are now in Government ownership. The holdings are being increased through purchases as rapidly as the funds available permit. At the close of the year the total of purchased lands reached 1,613,845 acres, while an additional 265,434 acres had been approved for purchase by the National Forest Reservation Commission.

Outside of the present eastern National Forests many other areas of rugged, broken, forested country are equally important in their relation to the maintenance of navigable streams and equally valuable as sources of forest production. Conspicuous among such areas are the Berkshire Hills of Massachusetts and Connecticut; the Kentucky River and Cumberland watersheds in Kentucky; the Current River region and St. Francis Mountains in Missouri; the Brown County section of Indiana; the Piedmont Plateau of Virginia, North Carolina, and South Carolina; and other areas in Texas, Oklahoma, Michigan, Wisconsin, Alabama, West Virginia, Mississippi, and Maryland. A reconnaissance to determine the need for an extension of purchase work to lands not now included within authorized areas was approved by the National Forest Reservation Commission just prior to the close of the year.

The three specific things the Government should endeavor to accomplish in its program of forest purchases are:

- (1) To complete the acquisition of areas having an important relation to the control of erosion and regulation of navigable streams.
- (2) To acquire for the future national supply of forest products timber-growing lands, chiefly denuded or cut over, which are located in the forest regions having the greatest importance from geographic location and productive possibilities. These should include a large proportion of lands whose reforestation will be difficult and ex-

pensive which therefore should be a public rather than a private obligation.

(3) To establish in the major forest regions now lacking them National Forests which will serve as demonstration areas of forestry practice. The attainment of these ends requires the removal of the present limitation upon purchases to areas within watersheds of navigable streams, in recognition of a national obligation to aid in the production of timber on forest lands generally.

This enlarged program would involve (1) the acquisition of approximately 3,000,000 acres on important watersheds in the Eastern States, within acquisition areas previously established by the commission and such new areas as may be found desirable, at an average cost not exceeding \$8.50 per acre, and (2) the acquisition of approximately 7,000,000 acres without special reference to the watersheds of navigable streams, but comprising chiefly lands which will not be reforested except under public ownership. The average cost of such areas would probably be within \$3.50 per acre. The total cost of such a program, which would require from five to ten years for accomplishment, would be \$50,000,000.

The importance and necessity of general legislation whereby the completion and adequate protection of the National Forests may be secured through consolidation by exchanges with private owners has been emphasized in an increasing degree by the developments of the past fiscal year. Aggregating 25,154,414 acres and amounting to almost one-seventh of the total gross area of the National Forests, these private lands constitute a growing problem both to the Government and to their owners. Located largely by the chance of grants in place, and rarely valuable for any purpose except forest production or associated uses, these lands lie interspersed among those under Government control and by their very location often jeopardize and hamper the effective management of the Government's holdings. Scattered as they are, the harvesting of the forest or forage products of the private lands involves heavy costs that would be unnecessary were the lands located in compact bodies. The value of the intermingled Government lands for like purposes is correspondingly diminished. The situation exists in some degree on almost every National Forest and can be met only by laws of general application.

At the close of the fiscal year 24 separate bills authorizing exchanges or consolidations were pending before the Committees on Public Lands of the Sixty-seventh Congress. The valuable results which will follow the enactment of these measures can not be disregarded, but they represent the piecemeal solution of a pressing problem which could better be worked out by general legislation. The process of consolidation by exchange will at best require many years of careful study and negotiation. Exclusive of exchanges with the several States, the number of exchanges with owners of private lands consummated during the past 10 years under authority of the several acts passed by Congress during that period has been 43, the land surrendered amounting to 141,522 acres and the land granted in lieu thereof to 101,665 acres. Values in each exchange have been carefully balanced with due regard to the Government's interests. The results demonstrate that exchanges afford means of materially enhancing the value of the Nation's forest properties, and legislation

permitting a more general and rapid adjustment of the matter is vitally necessary.

PROTECTION.

PROTECTION OF THE NATIONAL FORESTS.

The number, classes, and causes of the fires on the National Forests in the calendar year 1920, compared with those in the previous year, are as follows:

Comparison of fires on National Forests, calendar years 1919 and 1920.¹

Classes and causes of fires.	Number of fires.		Percentage o total.	
	1919	1920	1919	1920
Class of fire:				
Burns less than 0.25 acre	2,839	3,122	41.75	51.37
Burns between 0.25 acre and 10 acres	2,014	1,724	29.62	28.36
Burns 10 acres and over, damage under \$100	1,170	884	17.21	14.54
Burns 10 acres and over, damage \$100 to \$1,000	449	249	6.60	4.10
Burns 10 acres and over, damage over \$1,000	328	99	4.82	1.63
Total.....	6,800	6,078	100.00	100.00
Causes of fires:				
Railroads.....	701	508	10.31	8.36
Lightning.....	2,197	3,081	32.31	50.69
Incendiary.....	339	245	4.99	4.03
Brush burning.....	360	248	5.29	4.08
Campers.....	1,466	1,053	21.56	17.33
Lumbering.....	278	211	4.09	3.47
Unknown.....	1,155	485	16.98	7.98
Miscellaneous.....	304	247	4.47	4.06
Total.....	6,800	6,078	100.00	100.00

¹ Statistical records of fires, to have significance, must deal with complete seasons, and therefore cover calendar years.

The area of National Forest lands burned over was 342,193 acres, as against 2,007,034 in 1919; the estimated damage was \$419,897, as against \$4,919,769; and the total cost of fire fighting (exclusive of the time of Forest officers) was close to \$1,000,000, as against \$3,039,615. District 1 (Montana and northern Idaho) had much the largest number of fires (1,716), and had 25 of the 99 fires which caused damage in excess of \$1,000. District 6 (Washington and Oregon) had 1,385 fires, and district 5 (California) 1,338. Together, these three districts had 73 per cent of all the fires—exactly the same percentage as in 1919.

The figures given above reveal some instructive contrasts. While the total number of fires decreased 10.6 per cent, the number of lightning-caused fires increased 40.2 per cent. The decrease in man-caused fires was very marked, with a drop of 35 per cent. The number of campers' fires decreased 28.2 per cent, and this in spite of the fact that recreational use of the Forests is growing by leaps and bounds.

Again, not quite nine-tenths as many fires were fought, at about one-third the cost; they covered one-sixth the area, and did one-twelfth the damage. The number of fires which burned less than one-fourth of an acre was considerably greater than in 1919, while

less than one-third as many covered 10 acres and did over \$1,000 damage.

Any attempt at interpreting these data must take into account the great differences in the character of the two seasons. The general character and history of the 1920 season were summarized in last year's report. In contrast with the season of 1919, which both in length and severity was one of the worst that the West has ever known, it was short, but acute while it lasted. An unprecedented number of fires were caused by lightning, exceeding by 25 per cent the highest previous record.

Lightning fires are apt to be particularly hard to control, for two reasons: They occur most commonly in the high mountains, where they are hard to get at quickly, and they often occur in considerable numbers almost simultaneously, so that the protective force is taxed to the utmost to meet the strain without cracking. On one Forest in California—the Klamath—a series of storms started 48 fires within six days, while on the Trinity a single disturbance in one day started 70, besides causing a number of others on neighboring Forests. Under such conditions, to bring all the fires under control before they reach large dimensions is beyond human capacity with the present protective force and equipment. In district 6 (Oregon and Washington) practically all the fires requiring heavy expenditures to bring under control were lightning-caused.

The peak of the load occurred in district 1 (Montana and northern Idaho). Topography, climate, and wilderness conditions combine to make the problem of fire prevention in portions of western Montana and northern Idaho well-nigh insuperable at the present time. In this district, almost always characterized by extreme summer drought, the precipitation for June, July, and August was about two-thirds of normal. During the season there were 1,281 lightning fires—75 per cent of the total from all causes. And over 30 per cent of all the fires broke out within a single 10-day period.

A large outlay for fire fighting was inevitable under such conditions. Since the appropriation for fire fighting was only \$250,000, deficiency appropriations became necessary to replenish the general administration funds. Two such appropriations were made by Congress, totaling \$775,000. Fortunately, an exceptionally favorable spring and early summer, with late rains, resulted in expenditures in the latter part of the fiscal year far below what is normally required, so that at its close there remained an unexpended balance of \$50,000.

The 1921 season has continued, on the whole, favorable to the date of this report, and the expenditures for fire fighting have been decidedly below what must be looked for in years of normal hazard. Nevertheless, the fire-fighting fund for the fiscal year of \$250,000 has been exhausted and additional liabilities of approximately \$225,000 incurred. The greater part of the expenditures have been in Montana, Idaho, and California.

A hazard of unique character was created by the tremendous blow down of timber on the west side of the Olympic Peninsula, in Washington. Something like 6,000,000,000 feet of timber are estimated to be on the ground, creating the most formidable fire trap the Forest Service has ever had to reckon with. The bulk of the down timber is outside the Olympic National Forest, but if fire

were once to get underway in this almost impenetrable mass of huge fallen trees its control would be practically impossible, and large losses would undoubtedly be suffered by the National Forest. To meet this situation the Forest Service, under authority of a special deficiency item, has cooperated with the State authorities and private owners in maintaining the most intensive protection ever attempted in the United States. This is mainly a matter of organizing the entire local public to eliminate all human causes of fire. It is something of a triumph to have come through the first and probably most dangerous season successfully.

During the past 11 years, 42,000 "man-caused" fires have started in the National Forests. These are more than two-thirds of all the fires with which the Forest Service has had to contend. In organizing for more and more efficient protection, it would be the height of folly to overlook the principal source of fire hazard, which lies in human ignorance or indifference.

The use of the National Forests for industrial and recreational purposes is rapidly increasing. Thousands of people now traverse or camp in the National Forests where there were but scores or hundreds six years ago. The annual number of man-caused fires is a barometer of the hazard occasioned by this enormous increase in the use of the Forests, a barometer which must be watched with the utmost care. If the number of man-caused fires increases proportionately with the use of the Forests, the task of protecting them is well-nigh hopeless. From 1914 to 1917 there were from 4,300 to over 5,600 man-caused fires each year. Since 1917, while varying to a considerable degree, on account of climatic conditions, the movement has been downward. Last year approximately 3,000 fires were of human origin. While caution is necessary in drawing conclusions, it is probable that this result is due in part to the efforts of the Service in common with those of States and many private agencies to educate the public on the necessity for care with fire in the woods, to the increasing cooperation furnished by the press and by many commercial and semipublic agencies, and to a campaign of strict law enforcement against offenders.

There is no more important phase of fire protection than that of inculcating by every possible means the necessity for care in the use of fire on the part of every citizen and every industrial enterprise which uses or traverses the public forests. The forest fire evil, with its long train of costly destruction and emergency expenditure, can only be eradicated by public education. The proclamation of a "Forest Protection Week" by the President of the United States and by the governors of many States and the wide observance of this week, brought about through organized publicity and other educational efforts dealing with forest fires, were unquestionably of immense value.

Aside from attacking man-caused fires at the source, years of experience have only emphasized the truism that effectiveness in protecting forests is measured by the speed with which fires can be discovered and reached. The efforts of the Forest Service are concentrated on rounding up all the big and little means of securing

prompt discovery of incipient fires and quick action in reaching them. The main reliance for prompt discovery must be a lookout service, well distributed over peaks and other effective points and continuous during the daylight hours. The second essential is a network of telephone lines, inexpensively constructed by attachment to trees, so that the lookout can instantly communicate the alarm to the ranger, patrolman, or guard who is nearest the telltale column of smoke. About 3,000 fires are thus put out on the National Forests every year before they reach a quarter of an acre in size. But fires may be fanned by heavy winds or may run in inflammable slashings or may be so inaccessible that they can not be reached quickly enough to be extinguished single handed, particularly if many fires are started simultaneously by a lightning storm or by a defective locomotive on an upgrade. Quick action must then be possible in mobilizing the available rangers and guards, in equipping them with fire-fighting tools and supplies of food, and in drawing upon local settlers, miners, stockmen, and the crews of lumber camps for fire fighters. Such situations frequently occur and necessitate a warehouse and supply service whereby standardized equipment and foodstuffs can be furnished promptly in the quantities needed and an organization put quickly into action which extends from the base of supplies to the fire line, not unlike the organization needed for a military offensive.

Success in suppressing large fires in National Forests depends upon the completeness and perfection of this organization and its training in advance for dealing with every fire in every stage, with the utmost speed and without confusion or indecision. To bring its fire organization up to or near this ideal is the most important task of the Forest Service. It involves knowledge of technical appliances and methods and effective use of the crystallized experience gained in many years. Above all, it requires trained men who know the game. One of the outstanding needs of the Forest Service at the present juncture is to provide, even on a limited scale, for the systematic training of its field officers in the technique of fire control and suppression.

In recognition of the primary importance of an efficient fire organization, every possible effort has been made to increase the force of guards during the present fire season, at the cost of drastic cuts in other lines of work. With the appropriations made for the fiscal year 1922 it has been possible to add 68 men to the fire force in the four worst fire districts. The average forest ranger and guard in these districts, however, must still cover 52,000 acres. Experience has clearly demonstrated that this force is inadequate. Even during the average season, disregarding exceptional climatic hazards of frequent occurrence, it is not possible for the existing organization to reach and put out promptly a considerable number of fires which thereupon become large blazes and require heavy emergency expenditures. The loss in public property and in public funds from such emergencies, because the authorized force was too small to reach the fires in time, still continues. It will again be necessary to request Congress for a deficiency appropriation, because the fire-fighting resources provided in the regular budget were not adequate.

From the standpoint of appropriations, the outstanding need of the Forest Service in its business of protecting public property is to increase the summer guard force so that at least a larger proportion of the fires can be reached and extinguished when small and the necessity for emergency expenditures correspondingly reduced.

INSECT INFESTATIONS IN SOUTHERN OREGON AND NORTHERN CALIFORNIA.

A very serious infestation of tree-killing insects has been brought forcibly to public attention during the past year. One and a quarter million acres in southern Oregon and northern California, one of the finest bodies of pine timber remaining in the United States, are infested to a greater or less extent with bark beetles. The damage to date is estimated at \$3,000,000. Efforts have been made by a few private owners to eradicate the insects, but isolated attempts are unavailing in the midst of such an enormous area of infested timber. Of the forest area actually infested or menaced, approximately 250,000 acres are in the Klamath Indian Reservation, 100,000 acres in the revested Oregon and California land grant, 25,000 acres in the public domain, and 285,000 acres in National Forests. The remaining half of the total area is privately owned. An estimated stand of 10,000,000,000 feet of timber, valued at \$30,000,000, is threatened with destruction.

The State of Oregon has enacted effective laws for compelling the cooperation of private forest owners in ridding their timber of insects; but State and individual efforts will be futile unless the Government joins forces in wiping out the pest. The intermingled public and private timber must be cleared of beetles at the same time; otherwise no area will be safe from reinfestation. An estimate has therefore been submitted to Congress for a deficiency item of \$150,000, which will pay the cost of protective work on the Government's lands.

COOPERATION WITH STATES IN FOREST PROTECTION.

Expenditures from the appropriation of \$125,000 made by Congress for fire protection on the forested watersheds of navigable streams in cooperation with the States, and the expenditures of the States which have entered into cooperative agreements for this purpose, are shown in the following table. The lands protected are in State or private ownership.

Cooperative expenditures, fiscal year 1921.

State.	Federal.	State.	Total.
Maine.....	\$5,597.50	\$136,520.42	\$142,117.92
New Hampshire.....	6,795.17	37,003.70	43,798.87
Vermont.....	2,737.20	7,724.49	10,461.69
Massachusetts.....	3,137.00	51,297.95	54,434.95
Rhode Island.....	501.00	3,896.22	4,397.22
Connecticut.....	1,349.92	6,270.09	7,620.01
New York.....	7,678.61	183,577.47	191,256.08
New Jersey.....	2,703.37	30,643.40	33,346.77
Pennsylvania.....	9,079.81	108,196.70	117,276.51
Maryland.....	2,235.36	5,013.47	7,268.83
Virginia.....	5,852.50	11,533.88	17,386.38
West Virginia.....	5,603.50	7,150.49	12,753.99
North Carolina.....	2,226.00	5,052.77	7,278.77
Louisiana.....	1,634.50	11,466.25	13,100.75
Texas.....	3,751.02	4,309.42	8,060.44
Michigan.....	7,240.00	90,344.38	97,584.38
Wisconsin.....	2,904.25	14,569.86	17,474.11

Cooperative expenditures, fiscal year 1921—Continued.

State.	Federal.	State.	Total.
Minnesota.....	\$10,272.00	\$150,665.53	\$160,937.53
South Dakota.....	100.00	7,734.20	7,834.20
Montana.....	3,019.90	4,530.62	7,550.52
Idaho.....	3,681.36	87,078.77	90,760.13
Washington.....	7,499.00	46,810.59	54,309.59
Oregon.....	7,494.00	32,617.69	40,111.69
California.....	5,312.00	22,030.46	27,342.46
Administration and inspection.....	11,098.11	.....	11,098.11
Total.....	119,523.08	1,066,038.82	1,185,561.90
Unexpended balance.....	5,476.92		
Appropriation.....	125,000.00		

Cooperation in fire protection was continued with 24 States on the same basis as in recent years. A \$25,000 increase in the appropriation permitted urgent increases in the allotments to certain States. No new States qualified in time to receive allotments during the year, but Ohio, Tennessee, and New Mexico, enacted legislation under which cooperation can be extended next season. Kentucky, which it was hoped might resume the cooperation suspended somewhat over a year ago, has dropped out, owing to legislation which has completely crippled the State forestry work.

The year 1920 was the fifth consecutively for which statistics were obtained, in cooperation with State and private agencies, on forest fires in all parts of the United States so far as records are obtainable. During this period it is estimated that the number of fires averaged 32,517 annually, the area of forest land burned 7,560,000 acres, and the immediate property loss \$17,240,000. It is this condition, more than any other factor, which has caused the depletion of the timber supply of the United States. Seventy-nine per cent of the forest lands in the country, aggregating 369,000,000 acres, is in private ownership. Approximately 219,000,000 acres out of this total are wholly unprotected from fire, and on many other areas the protection is incomplete and inadequate. It is primarily because such a large proportion of our young forest growth has been burned up that the country is now taking out of its forests every year over four times the quantity of timber which is being grown. Already some 81,000,000 acres of forest-growing land have been so denuded as to become practically idle. On other enormous areas of cut-over land, the second growth forest is sparse and incomplete because of recurring fires.

Cooperation with the States in fire prevention, with reference primarily to the protection of navigable watersheds and in pursuance of the act of March 1, 1911, for the conservation of navigable waters, represents the first systematic and comprehensive step taken by the Federal Government toward checking this loss on the privately owned timberlands of the United States. In the decade following this step, the protection of private forest lands has been built up from almost nothing to a point where about one-third of the resource can be said to be adequately protected. In large measures as the result of Federal leadership and encouragement, the current expenditures for forest protection on the part of States and private owners are seven times the Federal appropriation for this purpose.

The extension of organized forest protection under this plan, with the Federal Government taking the lead as a standardizing and co-operating agency, is one of the most essential steps in our forestry policy. It should, as rapidly as possible, include all of the 39 States which contain important forest resources. Experience has demonstrated that the technical leadership and financial cooperation of Federal agencies are factors of the highest importance in initiating local protective organizations and in stimulating the expenditures of State and private funds for this purpose.

NATIONAL FOREST MANAGEMENT.

TIMBER.

The general business depression affected, of course, the lumber industry. Prices at the mill were in some cases less than half those received for the same grades a year previously. Many mills shut down and many more operated only part time. Yet the cut of National Forest timber increased 3½ per cent, and was larger than in any previous year. While the rate of cutting slackened noticeably toward the end of the year, the new sales exceeded in value and nearly equaled in amount those of the fiscal year 1920.

The decrease of 14.1 per cent in the receipts from timber sales, mentioned on page 8, in the face of an increased cut, needs explanation. Advance payments are required on timber sold. The drop in receipts was due partly to the slackening of operations late in the year, partly to disinclination of operators to tie up any larger sums in advance payments than was absolutely necessary. In short, at the close of the year considerably less money was in bond for timber still to be cut than was the case a year previously.

Both the cut and the sales (largely of timber for future cutting) show strikingly the stability of the National Forest timber business. This stability is an outcome of a sales policy which definitely aims at providing first for local needs and at making the Forests contribute to the support of permanent industries and stable communities. The policy aims also at encouraging the development of new enterprises of a kind and on a scale to utilize most effectively the raw material which the Forests can best produce, on a sustained-yield basis. On the White Mountain National Forest, in New Hampshire, for example, the timber management plans contemplate provision for the needs of permanent establishments for manufacturing boxes, bobbins, spools, toys, and other novelties, as well as for permanent pulp and lumbering industries. The local value of such enterprises, supporting wage earners, putting money in circulation, indirectly furnishing a home market for agricultural products, and thus contributing to the highest economic life of the region, is obvious.

On this Forest an allowable output of timber from each major watershed approximately equal to the annual growth has been determined. Cutting will be limited to this amount. At a result, local industries can count with confidence on permanent supplies of raw material, in contrast to the usual history of industries based on timber in private ownership, with operations conducted on a large scale for a few years, followed by exhaustion of the timber and migration to fresh fields.

Similar plans are being pushed for the National Forests in the southern Appalachians and Arkansas. It is of special importance that local farmers have opportunity for winter employment in getting out logs or other Forest products from the near-by National Forests when work on the farm is slack. Already many new permanent manufacturing industries have been established or transportation facilities installed as a direct result of the Forest Service timber management policy. It is being applied on all National Forests, including those of Alaska, where it is the intention to provide for permanency for the pulp and paper industry instead of a mushroom growth followed by exhaustion and local economic disaster.

A sale pending at the close of the year, and made since, on the Washakie Forest in Wyoming, covered an estimated quantity of 1,062,000 railroad ties, equivalent to about 40,000,000 board feet, and about 20,000,000 board feet of saw logs, which the purchaser may, if he desires, take for the production of sawed ties. He can also cut large amounts of mine props from the tops of the trees cut for ties. These products will be used locally, the ties by a railroad and the mine props in local coal mines. The hewn ties alone, at 5 cents each, will bring \$53,000 into the Treasury during the five years allowed for cutting and removing the timber. For eight years the purchaser has been operating on adjacent areas of National Forest timber, cutting chiefly ties, which are driven down streams too small to float saw logs and then 125 miles down a river to the railroad.

A sale in California will not only supply both local and general market needs for boxes and lumber, but will also aid greatly in the development of the locality. This sale is for about 600,000,000 board feet located in the Sierra Forest. The successful bidder has about 700,000,000 board feet on privately owned land adjoining and intermingled with the Government timber. He has agreed to build nearly 50 miles of main-line railroad, which will be a common carrier, and which, therefore, will serve all owners of property in a locality previously without good transportation facilities. On account of the intermingling of the private and Government lands and the large combined timber volume, a period of 30 years is allowed for cutting and removal, but the initial prices, \$4.25 per thousand board feet for sugar pine, \$3 for western yellow pine, and \$1.50 for other species, are to be readjusted in 1926 and at three-year intervals thereafter.

A sale of 84,000,000 feet of timber, chiefly western yellow pine, on the Crater National Forest in Oregon, will result in the resumption of operation on a short local railroad and bring a new lumber-producing industry into the locality. The lumber will be sold chiefly in the general market. Nine years are allowed for cutting and removal, of which the first two will be needed for the construction of improvements. The initial prices of \$3.75 per thousand board feet for pine and 75 cents per thousand for other species are subject to readjustment in 1925 and 1928, but even at the initial rates the total value of the timber is \$315,000.

In all sales, the future productiveness of the ground is assured by the retention of young, thrifty trees or of seed trees, and by

precautions against fire, including the disposal of the inflammable slash.

Timber sold fiscal year ended June 30, 1921.

State.	Board feet.			Value.		
	Commercial sales.	Cost sales.	Total.	Commercial sales.	Cost sales.	Total.
Alabama.....	15,000	.....	15,000	\$29	.....	\$29
Alaska.....	144,895,000	.....	144,895,000	154,422	.....	154,422
Arizona.....	12,674,000	647,000	13,321,000	33,968	\$544	34,512
Arkansas.....	6,126,000	236,000	6,362,000	35,783	208	35,991
California.....	359,286,000	2,002,000	361,288,000	1,230,927	1,135	1,232,062
Colorado.....	18,714,000	1,484,000	20,198,000	48,769	1,125	49,894
Florida.....	2,014,000	.....	2,014,000	7,715	.....	7,715
Georgia.....	1,078,000	.....	1,078,000	5,404	.....	5,404
Idaho.....	164,950,000	3,659,000	168,609,000	620,408	2,772	623,180
Michigan.....	32,000	12,000	44,000	140	9	149
Minnesota.....	2,775,000	.....	2,775,000	12,885	.....	12,885
Montana.....	192,850,000	5,520,000	195,370,000	505,512	4,489	510,001
Nevada.....	1,273,000	57,000	1,330,000	1,427	41	1,468
New Hampshire.....	2,655,000	.....	2,655,000	18,746	.....	18,746
New Mexico.....	13,566,000	1,667,000	15,233,000	39,145	1,092	40,237
North Carolina.....	1,532,000	.....	1,532,000	3,932	.....	3,932
Oregon.....	87,127,000	3,080,000	90,207,000	182,548	1,880	184,428
South Dakota.....	7,107,000	871,000	7,978,000	18,293	747	19,040
Tennessee.....	2,592,000	188,000	2,780,000	3,459	165	3,624
Utah.....	17,484,000	1,161,000	18,645,000	59,661	910	60,571
Virginia.....	5,964,000	39,000	6,003,000	24,188	32	24,220
Washington.....	88,519,000	657,000	89,176,000	150,037	363	150,400
West Virginia.....	665,000	.....	665,000	2,919	.....	2,919
Wyoming.....	14,337,000	676,000	15,013,000	34,850	539	35,389
Total, 1921.....	1,148,230,000	21,956,000	1,170,186,000	3,195,167	16,051	13,211,218
Total, 1920.....	1,294,446,000	32,476,000	1,326,922,000	3,026,186	21,559	3,047,745

¹ In addition, minor products, not convertible into board feet, were sold; value, \$4,004.

² In addition, minor products, not convertible into board feet, were sold; value, \$25,815.

Timber cut under sales, fiscal year ended June 30, 1921.

State.	Board feet.			Value.		
	Commercial sales.	Cost sales.	Total.	Commercial sales.	Cost sales.	Total.
Alabama.....	15,000	.....	15,000	\$29	.....	\$29
Alaska.....	36,881,000	.....	36,881,000	62,480	.....	62,480
Arizona.....	45,705,000	613,000	46,318,000	107,683	\$527	108,210
Arkansas.....	13,748,000	243,000	13,991,000	56,239	205	56,444
California.....	139,318,000	2,591,000	141,909,000	352,416	1,338	353,754
Colorado.....	44,208,000	1,341,000	45,549,000	108,852	1,014	109,866
Florida.....	1,515,000	.....	1,515,000	4,735	.....	4,735
Georgia.....	2,850,000	.....	2,850,000	12,808	.....	12,808
Idaho.....	121,406,000	4,116,000	125,522,000	334,622	3,163	337,785
Michigan.....	1,167,000	8,000	1,175,000	1,954	6	1,960
Minnesota.....	9,328,000	200,000	9,528,000	29,630	100	29,790
Montana.....	55,665,000	6,820,000	63,485,000	125,940	5,513	131,453
Nevada.....	1,207,000	25,000	1,232,000	1,600	17	1,617
New Hampshire.....	3,785,000	.....	3,785,000	21,436	.....	21,436
New Mexico.....	22,999,000	1,717,000	24,716,000	47,907	1,001	48,908
North Carolina.....	9,998,000	.....	9,998,000	28,527	.....	28,527
Oregon.....	126,098,000	4,214,000	130,312,000	262,527	2,429	264,956
South Dakota.....	21,880,000	589,000	22,469,000	59,102	484	59,586
Tennessee.....	7,583,000	196,000	7,779,000	9,927	160	10,087
Utah.....	10,477,000	891,000	11,368,000	27,044	705	27,749
Virginia.....	4,777,000	43,000	4,820,000	15,079	35	15,114
Washington.....	88,333,000	628,000	88,961,000	160,347	343	160,690
West Virginia.....	441,000	.....	441,000	1,986	.....	1,986
Wyoming.....	37,852,000	783,000	38,645,000	92,815	605	93,420
Total, 1921.....	803,246,000	25,018,000	833,264,000	1,925,745	17,645	1,943,390
Total, 1920.....	783,917,000	22,184,000	806,131,000	1,754,599	15,800	1,770,399

¹ In addition, minor products, not convertible into board feet, were cut; value, \$3,488.

² In addition, minor products, not convertible into board feet, were cut; value, \$10,381.

Number of timber sales, classified according to amount of sale, fiscal year ended June 30, 1921.

State.	\$100 or under.			\$101-\$500.	\$501-\$1,000.	\$1,001-\$5,000.	Over \$5,000.	Total.
	Commercial.	Cost.	Total.					
Alabama.....	4		4					4
Alaska.....	211		211	1	3	4	2	221
Arizona.....	646	308	954	3	3	4	1	965
Arkansas.....	30	95	125	4	3		1	133
California.....	484	322	806	20	5	12	7	850
Colorado.....	517	253	770	5	5	10	1	791
Florida.....	30		30	3	6	2		41
Georgia.....	42		42	1	1	2		46
Idaho.....	757	958	1,715	17	4	14	9	1,759
Michigan.....	3	3	6					6
Minnesota.....	4		4	1	2	5		12
Montana.....	773	1,514	2,287	22	7	13	7	2,336
Nebraska.....	3		3					3
Nevada.....	71	9	80					80
New Hampshire.....	144		144		1	1	1	147
New Mexico.....	672	668	1,340	4	3	5	2	1,354
North Carolina.....	144		144	2				146
Oklahoma.....	22		22					22
Oregon.....	326	534	860	16	5	8	5	894
South Dakota.....	348	180	528	4	2	1	1	536
Tennessee.....	58	52	110		1			111
Utah.....	337	610	947	7	1	2	2	959
Virginia.....	297	13	310	2	1		2	315
Washington.....	328	132	460	8	5	13	4	490
West Virginia.....	26		26			1		27
Wyoming.....	171		308	6	3	4	1	322
Total, 1921.....	6,448	5,788	12,236	126	61	101	46	12,570
Total, 1920.....	7,182	5,580	12,762	141	84	174	111	13,272

REFORESTATION.

The details of planting and sowing operations are given in the following table:

Planting and sowing on National Forests, by States, 1921.

State.	Area planted.	Area sowed.	Total.	State.	Area planted.	Area sowed.	Total.
	Acres.	Acres.	Acres.		Acres.	Acres.	Acres.
Michigan.....	908.80		908.80	Virginia.....		61.67	61.67
Montana.....	885.20		885.20	Alabama.....		8.00	8.00
Colorado.....	848.75		848.75	Florida.....		5.00	5.00
Idaho.....	801.80		801.80	New Hampshire.....		3.50	3.50
Minnesota.....	732.50		732.50	Arizona.....		2.00	2.00
Nebraska.....	431.25		431.25	Total.....	5,500.47	5.00	5,505.47
Washington.....	410.00		410.00				
Oregon.....	407.00		407.00				

The decrease in the appropriation for planting and sowing denuded areas on the National Forests from a prewar total of over \$170,000 to \$125,640 and the high cost of labor during 1921 are both reflected in the decreased acreage planted and sowed. The scale on which this work can be conducted with the available appropriation is small compared with the need. There are at least 1,500,000 acres of old burns within the National Forests, denuded chiefly before the creation of the Forests, which can only be restored to productivity

by planting. At the present rate its reforestation will require at least 200 years. The work is at present concentrated in those regions where the greatest success is obtained and where the need for artificial reforestation is greatest. For example, the notably successful plantations on the National Forests in Michigan and Minnesota are being extended, while the work in New Mexico, Utah, and California has been suspended. Work in other regions is being conducted on a necessarily reduced scale.

RANGE.

GENERAL CONDITIONS.

After the unusually severe winter of 1919-20 and the cold, backward spring of 1920 live stock throughout the entire West were in very poor shape; but, except in the extreme Southwest and some parts of the Northwest, the summer rainfall was timely and sufficient, stock fattened rapidly, and the calf and lamb crops for the year were fairly satisfactory. Throughout the Northwest and the Rocky Mountain region storms drove the stock from the higher ranges somewhat earlier than usual, but their owners were prepared to take care of them. A very mild winter in these regions was followed by excellent conditions last spring. More hay than usual was carried over, while the conditions for its production during the summer of 1921 were of the best. In fact, in every part of the West there are good prospects for cheap hay for feeding during the winter of 1921-22.

In Arizona, New Mexico, and southwestern Colorado, however, the entire summer of 1920 was extremely dry, and the stock went into the winter of 1920-21 in poor condition. An unusually light snowfall was followed by a very dry spring, with high winds, and the drought of the previous year continued. Watering places dried up, forage was very short, and by the first of July, 1921, the situation was deplorable. Subsequently, however, heavy rainfall saved the day. At the end of September grazing conditions in the Southwest were excellent, and most of the stock will undoubtedly enter the winter of 1921-22 in good condition.

USE OF THE RANGE.

The following table shows the number of stock on the National Forests under permits for the fiscal year 1921:

Grazing permits issued and number of stock grazed, 1921.

State.	Cattle, horses, and swine.				Sheep and goats.		
	Permits issued.	Number of stock grazed.			Permits issued.	Number of stock grazed.	
		Cattle.	Horses.	Swine.		Sheep.	Goats.
Alabama.....	9	213					
Arizona.....	1,455	351,622	4,044	530	144	312,227	4,030
Arkansas.....	224	3,159	46	51	2	12	48
California.....	2,831	203,341	6,064	1,133	504	544,832	9,391
Colorado.....	4,561	368,716	8,667	12	806	987,327	1,156
Florida.....	32	959	2	154	2	1,009	
Georgia.....	74	596	22	45	3	9	12
Idaho.....	4,061	176,457	12,537		996	1,634,610	
Montana.....	2,814	158,341	13,474		495	690,888	100
Nebraska.....	37	6,001	501				
Nevada.....	500	72,963	3,439		137	344,419	
New Hampshire.....	18	174	38				
New Mexico.....	1,925	170,154	3,495	414	543	384,144	28,357
North Carolina.....	363	1,960	71	553	29	355	
Oklahoma.....	43	1,953	109				
Oregon.....	2,360	153,595	8,340	56	540	734,420	96
South Dakota.....	805	35,492	2,699		4	2,200	
Tennessee.....	48	316			6	150	
Utah.....	6,942	162,153	8,048	228	1,796	800,672	
Virginia.....	245	2,346	4		5	132	
Washington.....	947	28,295	2,768		152	201,297	
West Virginia.....	7	35		1	1	9	
Wyoming.....	1,259	150,574	4,503		375	773,700	
Total, 1921.....	31,560	2,050,715	78,871	3,177	6,540	7,412,412	43,190
Total, 1920.....	31,301	2,033,800	83,015	4,066	6,199	7,271,136	53,685
Increase.....	259	16,915			341	141,276	
Decrease.....			4,144	889			10,495

FINANCIAL CONDITION OF STOCK INDUSTRY.

The stockmen using the National Forest ranges have felt severely the serious economic depression of the past year. This situation is a part of the generally adverse conditions affecting all agricultural industries throughout the country. Cattle prices were very disappointing. In the Southwest, where a large number of young steers are annually shipped from the Forest ranges, many owners were unable to find purchasers at any price. As a result spring deliveries from many localities for 1921 were much smaller than usual. Several shipments of range cows which went to market from various points in the West were reported to have brought less than the freight, and in a number of other instances netted the owners but \$1 or \$2 a head.

On the whole, sheepmen have suffered more than cattle producers from the present depression in live stock in consequence of the staggering drop in wool prices. Fairly satisfactory prices for the spring lamb crop of 1920 was the only encouraging factor. Financial conditions forced the sheep owners to sell down closer on their lamb crop than for many years past, so that the carry over includes fewer young ewes than normal. In spite of the depression in the sheep business, many stockmen are changing from cattle to sheep. Low prices for stock sheep offer a favorable opportunity to get into the business, while the returns from sheep, coming twice a year, make it more attractive.

POSTPONEMENT OF GRAZING FEES.

In order to make certain that each range will be used every year and as a necessary requirement in the disposal of public resources of commercial value, the regulations of the department require that all grazing fees be paid at least 30 days before the opening of the grazing season. The financial stringency appeared to justify an exception to the rule this season, and early in February, 1921, the Forest Service recommended to the Secretary of Agriculture its relaxation. Congress, with the favorable recommendation of the Secretary of Agriculture, passed an act authorizing postponement to September 1 of the payment of all grazing fees for the calendar year 1921. As the season advanced, however, it became evident that many stockmen would not be able to meet their obligations on that date, and further legislation was enacted, extending the time of payment to December 1, so that permittees might secure funds through marketing their surplus stock at the end of the season. The amount involved in this postponement is shown in the following table:

Grazing fees, paid and postponed, fiscal year 1921.

District.	Total paid, by classes of stock, to June 30, 1921.		Total paid to June 30, 1921.	Total unpaid, by classes of stock, on July 1, 1921.		Total unpaid on July 1, 1921.	Total receipts for fiscal year 1921 if all were paid.
	Cattle.	Sheep.		Cattle.	Sheep.		
1.....	\$46,344	\$23,266	\$69,610	\$74,329	\$53,072	\$127,402	\$197,013
2.....	46,961	10,171	57,132	250,520	126,602	377,120	434,252
3.....	63,350	11,817	75,167	412,910	105,499	518,409	593,576
4.....	65,756	35,579	101,335	268,736	312,066	530,803	682,138
5.....	57,365	29,955	87,320	94,938	53,745	148,683	236,003
6.....	35,778	15,584	51,362	111,341	94,582	205,924	257,257
7.....	9,557	128	9,685	5,509	154	5,664	15,349
Total.....	325,111	126,500	451,611	1,218,283	745,720	1,964,005	2,415,618

TOTAL RECEIPTS.¹

	Cattle and horses.	Sheep and goats.	Total.
Fiscal year 1921 if all are paid.....	\$1,543,394	\$872,220	\$2,415,618
Fiscal year 1920.....	1,549,390	877,638	2,427,028

¹ Grazing trespass fees not included.

The use of the range in the fiscal year 1921, as shown by the table on page 23, was apparently greater than in the fiscal year 1920, while the total of the fees, paid and unpaid, is shown above as less. The discrepancy is caused by the fact that the fiscal year is an artificial and confusing time division to use in statistics relating to use of the National Forest ranges. The accident of a late or early season or the financial circumstances of individual stockmen may cause a shifting of the date on which the stock enter the Forests or on which receipts are credited sufficient to make accurate comparison of two succeeding fiscal years impossible. For this reason as well as to lessen the burden now imposed on the field force by the necessity of making up statistical reports in the midst of the field season, with its many demands on their time, the figures showing use of the range will in future be given by calendar instead of fiscal years.

RANGE APPRAISALS.

The field work necessary for appraising the value of the National Forest live-stock ranges under the plan announced in last year's report was begun. The objective is an accurate classification of each range unit, based on the character of forage, the water supply, topography, nearness to shipping points, ease with which stock can reach them, and other factors affecting their grazing value. A uniform charge is now made for the use of all ranges within a Forest or group of Forests. Some range allotments, however, are worth far more than others. The work now under way will make it possible to base the grazing fees for each particular range unit upon its actual value to the stockmen.

The five-year grazing permits now in effect do not expire until the close of the grazing season of 1923. Consequently no change in the grazing fees can be fairly put into effect before the grazing season of 1924. Good progress is being made with the classification project, and the Forest Service is now sanguine of being able to complete the field work, review the assembled data, and arrive at a decision by that time. The permittees are cooperating with the Service in its field study, and before final action is recommended the stockmen, through their advisory boards, will be given full opportunity to present their views, evidence, and arguments on the fairness of the fees contemplated.

NEED FOR MORE GRAZING EXPERTS.

Each season accentuates the urgent need for more grazing experts. First among the reasons is a demand for grazing privileges far in excess of the carrying capacity of the ranges. This demand is steadily increasing in volume and insistence. Stockmen who for many years grazed their animals on the public domain now find their accustomed ranges so cut into by grazing homesteads that they are forced either to secure grazing privileges on the National Forests, to purchase private lands, or to go out of business. Many of the larger companies were farsighted enough to invest heavily in grazing lands as a protection against the loss of their public domain range; but the economic transition which the open range live-stock industry is passing through is causing the average stockman no little concern. This comes at a time of great financial stress. It is therefore doubly desirable that the full carrying power of the National Forest ranges be quickly developed. But these ranges have just passed through a severe emergency period. During the war some of them were overstocked to meet the need for increased food production, with the understanding that the increases allowed were merely temporary. Other ranges were overgrazed because the force of trained grazing business experts was depleted during the war period. Such temporary overstocking and overgrazing must be remedied before the numbers of stock can be further increased.

Overgrazing follows the lack of proper application of specialized knowledge as to the character of the range itself, its true carrying capacity, the class of stock for which it is best fitted, the seasons during which the stock should properly be on the range, and similar matters. Aside from the fact that the rangers and supervisors are

already so loaded with other administrative duties that they usually can not make the close study and investigation of the ranges necessary for their full development and most beneficial use, such work must be done by specially trained men. Without them the devising and application of sound, far-reaching plans of grazing management is impossible. The benefits of such plans are large in volume and quickly realized. Every dollar invested in them brings the Government a good return. Over and over this has been proved either by the increased number of stock carried after the plans are applied or by the possibility of maintaining without injury a volume of use which previously resulted in overstocking. The increased receipts for grazing thus secured do not stop with one season, but continue year after year.

The stockmen who have seen the splendid results where it has been possible to carry on this work, are naturally anxious to have it extended because of its benefits to the live-stock industry. The future of the live-stock industry in the West, especially that of sheep grazing, is closely tied up with the National Forest ranges. In addition to their direct use, they have great value as object lessons. Nearly all the holders of large grazing areas in the West, such as railroad and land companies, are now attempting to handle their ranges along the same lines as does the Forest Service. Its methods are constantly being studied and adopted, to the benefit not only of the landowners but also the stockmen and, indeed, the general public. In short, the work that is being done by the grazing experts of the Forest Service is of a permanently constructive character. By it the carrying capacity of the National Forest ranges, which has been markedly increased over their carrying capacity as parts of the public domain, is being still further augmented. To graze successfully three head of stock where two grazed before is equivalent to increasing the area of our range by 50 per cent. There is every reason for expanding the grazing investigations upon which depend expert range administration, and increased funds for this purpose are justified alike on grounds of sound economics and of good business practice.

RECREATION AND GAME.

Outdoor recreation ranks to-day as one of the major resources or utilities of the National Forests, not because of anything the Government has done to facilitate or increase this form of use, but because of the demonstrated belief of several millions of people that the Forests offer a broad and varied field of recreational opportunity. The presence of large numbers of people on favored recreation areas creates problems of sanitation, of public health, and of protection of public property which can not safely be ignored.

Counties, municipalities, forest recreation associations and other semipublic organizations, and in some cases individual citizens are doing much by generous donations and constructive planning to relieve the situation. They have installed toilets, fireplaces, shelters, sources of water supply, tables and benches, refuse depositories, parking places, and other almost indispensable facilities. Many camp grounds have thus been developed in comfort and beauty far beyond the standards the Government would seek to attain. The Cajon Pass Camp Ground, on the Angeles National Forests in southern

California represents investments of private funds amounting to over \$25,000, a sum almost equal to the entire amount of official funds expended for comparable work on all the National Forests. Several municipal camps are examples of the high public service which camp-ground improvements promote.

After the fullest possible cooperation has been secured, however, there will remain many important recreation areas where action by the Government will be necessary to preserve public health and property. The people can not be excluded from the Forests, and conditions endangering their health and that of others can not be regarded with indifference. The Government should install necessary sanitary and protective facilities upon camp grounds where other means of improvement are unobtainable. The estimate submitted of \$10,000 to meet the cost of work of this kind during the fiscal year 1923 is but a tithe of the amount needed, but it will provide for a few of the most urgent cases.

The full recreational development of the National Forests, however, should not depend wholly upon public action. Private initiative and capital will no doubt furnish the public with some of the facilities it needs, under the encouragement of reasonable terms and with acceptance of reasonable limitations. Much of the recreational resource may properly be made available for commercial development under conditions safe-guarding the public against poor service, discrimination, or extortionate charges. Rentals derived from occupancy under permit of National Forest lands constitute a permanent and rapidly growing source of income. In course of time the innumerable nooks and corners within the Forests which may be devoted to special uses will return a revenue largely reimbursing the costs of administration and improvement. Even under present conditions this activity is more than self-supporting.

In general, there is a broad competition between industrial and recreational uses, and within the latter class competition exists between one form of use and another. The relative public importance of various forms of special use to which a given area may be adapted or devoted must be ascertained and defined so that major values shall not be sacrificed to minor ones. The inherent values of Forests or parts of them must be studied and plans of land occupancy formulated which will conserve the maximum utility of the areas. The actual work of construction must be supervised. These duties demand the specialized skill and training of competent recreation engineers, under whose direction the occupancy of Forest lands under special-use permits could be better coordinated with other forms of use and made more permanent and effective. It is regrettable that funds are not available for the employment of a limited number of men of this class.

The use of the National Forests as the habitat of wild game is of considerable public importance. The presence of game adds to their attractiveness not only to hunters but to occupants generally, and anything that contributes to the abundance and variety of game increases the value of the Forests for public purposes. The same thing applies to fish in the Forest streams. The Forest Service has a corresponding duty and obligation. It cooperated during the year with the Biological Survey, the Bureau of Fisheries, and State authorities in fish and game matters.

Game in the National Forests presents a combination of problems—biological problems, legal problems, and range problems. The latter apply particularly to the larger ruminants, such as moose, elk, and deer. The most important range problem arising through the presence of game in the National Forests is in the immediate vicinity of the Yellowstone National Park, where about 1,650,000 acres are devoted primarily to the protection of elk herds, whose range, particularly during the summer, is largely within the park. Lack of winter range during unfavorable years has played havoc with these herds. In contrast with the severe winter and heavy losses of 1919-20 the winter of 1920-21 was open, the feed upon the winter elk ranges more than ample for their needs, and the elk wintered in fine shape. The spring of 1921 was favorable for the crop of young elk calves, which, from all information, was unusually good; and, as the summer of 1921 was one of fine forage growth, the losses among the calves were very slight. In all probability this fine calf crop will go a good way toward filling up the ranks of the combined herds, which were depleted by the losses of the winter of 1919-20. Both the Jackson Hole herd and the northern herd have had a favorable year. The latter herd remained well within the boundaries of the Yellowstone National Park until late in the season. Probably not more than 150 elk were killed by hunters last fall along its entire northern boundary. This gain has been supplemented by an almost complete stop of the inroads on the herd by poachers and tusk hunters through a winter patrol along the northern boundary of the Yellowstone National Park by officers of the Forest Service during the last four seasons.

But the stopping of poaching and one good season do not solve the problem, which is essentially one of winter range. Some provision, though inadequate in amount, was made years ago by the Federal Government for the Jackson Hole herd through purchases of hay and through additions to the Forest under authority of Congress; but the northern herd is left with a most unsatisfactory winter refuge.

To meet this situation the remaining public lands lying along the Yellowstone River and between the Absaroka and Gallatin National Forests should be added to these Forests. The lands are now under Executive withdrawal in response to the urgent recommendation of the Forest Service, the Biological Survey, and the National Park Service, but action by Congress is necessary to make the addition. Use of these lands for winter range for the elk must take into fair consideration the needs of local settlers for range for domestic stock. The Service has increasingly urged early action by Congress to the end that the addition may be made, so that the elk may be safeguarded against annihilation during some unfavorable winter, while at the same time the range of the local stockmen may be adjusted to the new order without resulting hardship.

One of the outstanding requirements for the perpetuation of the game resources of the National Forests is a considerable number of small, well-distributed game refuges, within which the rapidly diminishing stocks of valuable mammals and birds may rear their young free from molestation, thus maintaining upon the surround-

ing lands a normal overflow or drift to supply the hunter, naturalist, and lover of the wild. The National Forests contain many areas remote, inaccessible, and largely unsuited for the grazing of domestic stock, which might advantageously be devoted to this purpose. The dedication of such areas to the protection of game would be purely a function of land management, the State's control over the game being unaffected. Several excellent bills are now pending in Congress. A law of this kind, generally applicable to all National Forests, should be enacted.

Supplementary to the establishment of suitably located game refuges which would serve as breeding places, there should be definitely formulated plans for wild-life administration. In developing such plans the Forest Service looks to the Biological Survey for expert advice and assistance, just as it looks to the Bureaus of Entomology and Plant Industry for aid in protecting the National Forest timber supplies against insect infestations and tree diseases. The animal life of the Forests—that is, their native population, beast, bird, and fish—should be regarded and handled in precisely the same way as their plant life—their tree growth and forage growth. Under skillful management the quantity produced can be increased, its kind regulated, and its most desirable utilization secured. The wild life of the Forests has various kinds of values—material, esthetic, scientific, educational. All should be recognized. Unregulated use means its impairment; intensive use, often its eventual destruction as a resource. Expert knowledge of all the factors that determine its amount and character on a given area, combined with a just appraisal of all the human services and values realizable from it, are fundamental requisites for its proper administration.

Both the propagation and utilization of wild life can then be provided for. Much greater progress has been made toward an intelligent handling of fish in the Forests than of game and fur-bearing animals. It is certain, for example, that beaver could be bred in far greater numbers than at present, could be restricted to localities where they would not be detrimental to agriculture, and could be made a source of revenue of considerable importance. Their multiplication under a wisely worked-out plan might be made to increase the quantity of water available for irrigation, while trapping their natural increase might become a valuable privilege for those living in or near the Forests. Obviously a balance should be maintained between production and utilization, once a locality has become as fully stocked as, all things considered, is desirable. Obviously also there must be correlation between the management plans of the Forest Service having in view the best handling of National Forest wild-life resources and State laws relating to game and other forms of wild life. Already legislation of a character making this possible has been enacted in some States.

WATER POWER.

The Federal water power act of June 10, 1920, restricted the authority of the Secretary of Agriculture on water power matters to the administration of permits under the act of February 15, 1901, and of transmission line easements under the act of March 4, 1911, granted prior to the passage of the Federal water power act. This

act has been interpreted to mean that the Secretary of Agriculture may revoke privileges granted under the two earlier acts, may extend the period for completing construction and beginning operation of projects under final power permit issued under the act of February 15, 1901, but may not grant extensions of time under preliminary power permits, transfer any permit from the permittee to some other company, or permit the use of lands outside the right of way covered by the final permit. Because of the greater security of tenure given by the Federal water power act, its enactment was expected to lead to many applications for the substitution of licenses under it for final power permits issued under the act of February 15, 1901. No applications of this kind were received during the fiscal year. This probably is because permittees wished first to understand fully what regulations would be issued under the Federal water power act and how the law and regulations may affect power developments. Consequently there were in effect on June 30, 1921, all of the permits or easements granted by the Secretary of Agriculture except those final power permits which have been relinquished or revoked and those preliminary permits which had expired through failure to file final application within the specified time. The following tabulation presents data concerning them:

Water-power development and transmission-line rights of way under permit or easement fiscal year 1921.

Class of permits or easements.	Transmission lines only.			Power projects (reservoirs), conduits, and power houses.		Total number permits or easements.	
	Number of permits or easements.	Length in miles.		Number of permits or easements.	Estimated average output (in horse-power) at minimum discharge.		
		Within National Forest boundaries.	On National Forest land.				
Permits or easements in force at close of fiscal year:							
Rental—							
Preliminary.....							
Final.....	151	1,152.98	878.65	9	190,579	9	
Free permits or easements.....	23	154.33	126.84	89	682,071	240	
Total.....	174	1,307.31	1,005.49	197	899,414	371	
Construction completed at close of fiscal year:							
Rental permits or easements.....	150	1,067.88	805.22	74	346,150	224	
Free permits or easements.....	23	154.33	126.84	84	7,216	107	
Total.....	173	1,222.21	932.06	158	353,366	331	
Construction incomplete at close of fiscal year:							
Rental permits or easements.....	1	85.10	73.43	16	332,015	17	
Free permits or easements.....				14	16,965	14	
Total.....	1	85.10	73.43	30	348,980	31	
Constructed not started at close of fiscal year:							
Rental permits or easements.....					8	197,053	
Free permits or easements.....				1	15	1	
Total.....				9	197,068	9	

While it was anticipated that the Federal water power act would bring about a great revival of interest in power development, the applications filed are far in excess of all expectations. One of the interesting features has been the amount of proposed development in Alaska. Twenty-five applications, involving capacities of 180,000 horsepower, were filed during the year. Of these, 12 projects, with a total capacity of 130,000 horsepower, as estimated by the applicants, are intended to be used in the manufacture of pulp and paper, from timber to be obtained almost exclusively from the National Forests. Of 229 applications received by the Federal Water Power Commission for projects which the applicants estimate as having a capacity of 14,669,800 horsepower, 124 applications of 3,706,225 horsepower were for projects within or partly within the National Forests. The amount of proposed development in California is astonishing; 71 applications, involving 3,128,680 horsepower, were filed, of which 62 applications, involving a development of 3,081,765 horsepower, are located within, or partly within, the Forests.

The Federal water power act provides that the work of the power commission shall be performed by the three Departments of War, Interior, and Agriculture, and their engineering, technical, clerical, and other personnel, except as may be otherwise provided by law. It has been necessary for the three departments not only to loan employees to the power commission for work in Washington, but also to make all field investigations and reports and to hold all hearings except the few that could be handled by the commission itself at Washington. At the end of the fiscal year the Department of Agriculture was loaning 11 employees to the power commission, five of whom were from the Forest Service, entailing a charge against the Forest Service appropriations of more than \$1,000 a month. In the field districts also much time is required from Forest officers. Water-power work cost over twice what it did the year before, and will evidently cost still more this year. Relief from this burden is greatly needed. Either the commission should be authorized to pay the salaries of the employees engaged upon its work or the appropriations of the departments paying but not utilizing them should be correspondingly increased.

ROADS, TRAILS, AND OTHER IMPROVEMENTS.

The active prosecution of road and trail work, largely stopped during the war and started anew in 1919, was continued. The year witnessed the peak of high prices. This and a scarcity of efficient labor made impossible the construction of as many miles of road with the available money as was planned. The average cost of road and trail construction, repairs, and maintenance was about 70 per cent higher than in 1919. In the late fall costs decreased slightly, labor increased in efficiency, and contractors were more desirous to get work. This change grew more pronounced during the winter, and last spring contracts were let at amounts materially less than the engineering estimates. Unemployment conditions are indicated by the great increase in the number of contractors now submitting bids.

The following tabulation shows the mileage of roads and trails constructed, repaired, and maintained during the calendar year 1920,

the total mileage at the end of the year, the total expenditure to date, and the amounts expended from the Forest road appropriations and from cooperative funds. These figures include major work handled under the immediate supervision of the Bureau of Public Roads as well as the comparatively simple work done directly by the Forest Service.

Construction, improvement, and maintenance of roads and trails from Forest road appropriations and other Federal and cooperative funds by States.

State.	Calendar year 1920.		Total to Dec. 30, 1920.		Expenditures to Dec. 30, 1920.		
	Roads.	Trails.	Roads.	Trails.	Federal.	Cooperative.	Total funds.
	Miles.	Miles.	Miles.	Miles.			
Alabama.....					\$218.23		\$218.23
Alaska.....	37.5	3.8	84.7	15.1	369,459.60	\$85,787.16	456,276.76
Arizona.....	95.3	141.4	244.9	204.5	591,938.72	363,243.36	955,182.08
Arkansas.....	21.5	4.5	69.7	17.4	187,432.64	24,607.57	212,040.21
California.....	68.7	213.7	304.8	410.5	1,539,163.84	426,257.19	1,955,421.03
Colorado.....	89.8	69.9	253.5	239.3	1,176,149.38	323,005.82	1,499,155.18
Florida.....	3.5		53.0		60,442.75	58,030.00	118,472.75
Georgia.....	1.0	11.5	1.0	13.0	10,670.93	2,000.00	12,670.93
Idaho.....	250.8	342.0	712.9	518.4	1,523,123.10	574,571.23	2,097,694.35
Kansas.....			3.4		2,111.51		2,111.51
Maine.....		8.0		30.0	5,508.80		5,508.80
Michigan.....	2.4		33.3		1,512.67		1,512.67
Minnesota.....	3.0		8.4		55,946.64	13,997.87	69,944.51
Montana.....	104.9	97.3	365.1	136.9	1,010,070.29	283,245.42	1,293,315.62
Nebraska.....	3.8		7.4		7,203.81		7,203.81
Nevada.....	27.4	41.5	170.9	90.0	148,512.61	88,481.23	236,993.84
New Hampshire.....		9.0	5.0	211.8	12,250.47	220.25	12,470.72
New Mexico.....	78.6	209.1	178.2	343.0	635,222.56	137,761.58	773,984.14
North Carolina.....	4.0	12.8	4.0	31.0	75,639.64	2,499.82	78,139.46
North Dakota.....			1.0		65.75		65.75
Oklahoma.....					3,916.48	1,811.25	5,727.73
Oregon.....	275.4	131.4	753.0	307.1	1,184,802.48	864,068.97	2,048,871.45
Porto Rico.....		4.0		20.0	2,396.13		2,396.13
South Carolina.....					68.13		68.13
South Dakota.....	20.0		44.0	3.0	139,854.30	58,470.39	198,324.69
Tennessee.....	3.7	15.5	3.7	15.5	23,036.97	20,497.41	43,501.38
Utah.....	155.6	210.0	554.8	486.0	666,452.13	364,502.95	1,030,955.09
Virginia.....	1.5	29.5	4.0	50.5	21,781.85	2,409.91	24,191.76
Washington.....	116.0	110.3	234.7	284.0	959,856.13	618,135.04	1,578,021.17
West Virginia.....					772.42		772.42
Wyoming.....	80.2	102.6	229.1	220.0	623,334.17	111,244.56	734,578.73
Total.....	1,444.6	1,767.8	4,324.5	3,647.0	11,039,997.07	4,425,349.02	15,465,846.09

The following tabulation indicates the condition of the three road appropriations on January 1, 1921:

Condition of road appropriations.

Fund.	Total appropriations to Dec. 31, 1920.	Total expenditures.	Unexpended balance.
"10 per cent" ¹	\$2,794,251.21	\$2,161,482.24	\$632,768.97
"Section 8" ²	5,000,000.00	3,222,240.43	1,777,759.57
"F. F. R. C." ³	9,000,000.00	5,167,519.77	3,830,697.23
Total.....	16,794,251.21	10,551,242.44	6,243,008.77

¹ 10 per cent of the National Forest receipts of the previous year; made available by agricultural appropriation acts of Aug. 10, 1912, and Mar. 4, 1913.

² Made available by sec. 8 of the Federal-aid road act of July 11, 1916.

³ Federal forest road construction fund; made available by sec. 8 of the Post Office appropriation act of Feb. 28, 1919.

The distribution among the States of the total appropriations and of the appropriations for the fiscal year 1922 is given in the following tabulation:

The distribution among the States of the total appropriations and of the appropriation for the fiscal year 1922.

State.	10 per cent fund. ¹		Section 8 fund. ²		Total Federal Forest road construction. ³	Total.
	Fiscal year 1922.	Total.	Fiscal year 1922.	Total.		
Alabama.....	\$78.69	\$199.64	(B)	\$60.00	\$508.13	\$767.77
Alaska.....	5,902.54	69,384.39	\$44,587	284,610.57	172,736.50	526,731.46
Arizona.....	16,972.20	310,935.82	55,311	355,997.05	424,713.91	1,091,646.78
Arkansas.....	4,920.99	46,980.51	9,761	89,364.60	133,134.22	274,479.33
California.....	52,962.76	4'3,805.48	136,780	891,127.25	1,071,723.27	2,366,656.00
Colorado.....	17,141.75	222,139.96	64,238	435,718.31	737,714.87	1,465,573.14
Florida.....	1,504.54	13,824.92	(A)	50,955.67	23,834.40	94,614.99
Georgia.....	564.28	2,036.00	(B)	143.17	177,649.97	179,829.14
Idaho.....	27,417.88	347,508.22	110,773	680,780.59	1,245,811.68	2,274,100.49
Kansas.....		1,977.32				1,977.32
Maine.....	185.99	649.39	(B)	169.01	3,583.75	4,402.15
Michigan.....	217.08	719.39	(A)	15.00	3,000.00	3,734.39
Minnesota.....	1,363.73	13,221.65	(A)	511.65	98,721.76	112,455.06
Montana.....	19,070.81	324,815.27	70,182	452,548.32	701,655.36	1,479,018.95
Nebraska.....	59.54	9,290.81	(A)	26.98		9,317.79
Nevada.....	2,542.73	75,826.50	18,689	121,160.45	100,710.08	297,697.03
New Hampshire.....	2,216.96	8,424.80		166.10	9,419.28	18,010.18
New Mexico.....	8,596.45	189,219.13	38,817	254,904.61	480,988.50	925,112.24
North Carolina.....	3,080.49	9,898.41	(B)	912.99	160,002.56	170,813.96
North Dakota.....		156.79		15.00		171.79
Oklahoma.....	336.68	4,220.00	(A)	49.45	2,555.26	6,824.71
Oregon.....	29,282.72	316,370.48	128,661	821,834.77	900,349.06	2,038,554.31
Porto Rico.....		3.70	(A)	15.00	2,816.13	2,834.83
South Carolina.....	58.66	255.28	(B)	60.00	508.13	823.41
South Dakota.....	6,272.17	60,060.11	7,964	50,744.24	73,888.09	184,662.44
Tennessee.....	1,782.69	5,857.12	(B)	59,166.39	27,051.20	92,074.71
Utah.....	7,265.56	185,863.61	39,956	268,287.26	457,061.90	911,212.77
Virginia.....	2,312.89	9,654.41	(B)	68,054.38	69,506.54	147,215.33
Washington.....	22,051.60	180,547.65	89,862	590,863.63	720,579.75	1,491,991.03
West Virginia.....	444.18	1,235.77	(B)	128.64	3,137.69	4,502.10
Wyoming.....	13,390.63	157,165.87	42,778	264,595.17	582,382.10	954,143.14
Group I (A).....				12,049	12,049.00	12,049.00
Group II (B).....				29,572	29,572.00	29,572.00
Special fund.....				100,000	209,392.75	209,392.75
Equipment.....						183,244.65
Administrative expenses.....						183,244.65
Unallotted balance.....						143,779.91
						332,231.35
Total.....	247,997.19	3,042,248.40	1,000,000	6,000,000.00	9,000,000.00	18,042,248.40

¹ 10 per cent of the National Forest receipts of the previous year: made available by agricultural appropriation acts of Aug. 10, 1912, and Mar. 4, 1913.

² Made available by sec. 8 of the Federal-aid road act of July 11, 1916.

³ Federal forest road construction fund; made available by sec. 8 of the Post Office appropriation act of Feb. 28, 1919.

The plans for the calendar year 1921 contemplate work on about 700 miles of road and 1,800 miles of trail. This construction, together with plans, commitments, and obligations entered into which have not been consummated on account of unanticipated heavy advance in costs, will exhaust the unexpended balance of all road and trail appropriations already made with the exception of the 10 per cent fund, which must hereafter be devoted largely, if not exclusively, to trail maintenance work.

Plans have been drawn for a transportation system of roads and trails that will adequately serve the needs of the public and also the National Forests and encourage their development and utilization.

tion. These plans include 39,000 miles of road and 74,000 miles of trail, of which 25,360 miles of road and 34,720 miles of trail have already been constructed, but upon which a considerable amount of relocation, reconstruction, and repair is necessary to make them safe and satisfactory for travel.

Many large areas are still entirely without even the simplest trail facilities. Valuable forests which will be urgently needed in the future are being jeopardized by reason of the fact that they are without adequate roads or trails by which fire-fighting supplies and men may be brought in in case of need. The primitive conditions existing on some of the Forests are but little realized. Many sections are entirely without roads, while others are served by roads which are simply wagon tracks through the woods, and are narrow, dangerous, steep, and entirely unsuited to travel.

This condition subjects great natural resources to grave and unwarranted risks. It increases our annual costs for fighting forest fires, increases our annual losses, and reduces the usefulness of the property protected. At the same time it retards local development, discourages the scattered settlers who can not build the roads they need unaided, reduces the value of their products and adds to the cost of their purchases, acts as a barrier against social intercourse and school privileges, adds to their isolation, and breeds discontent. The construction of National Forest roads and trails for the protection and development of the Forests should properly be viewed as an investment rather than an expense. To thus improve the public properties increases their value out of proportion to the sums invested, secures them against waste, and recognizes a civic obligation imposed on the Federal Government by extensive land ownership in a community.

During the past five years the average annual loss of National Forest timber by fire was approximately \$1,500,000, and the cost of extinguishing fires about \$1,200,000. An adequate system of roads and trails would materially reduce both items, would be of great public utility for general travel and traffic, and would further serve the public by lessening the destruction of resources essential to local prosperity. The system of transportation should be completed at the earliest practicable date consistent with other pressing public needs. Fires will not await our convenience. A number of measures are now pending which would make funds available for continuing the work upon a fairly adequate basis. Next to the integrity of the title to the soil itself, nothing more vitally affects the future of our National Forests.

RESEARCH.

SILVICAL INVESTIGATIONS.

The outstanding event of the year was the completion of plans for establishing on a small scale two new forest experiment stations, opened on July 1, 1921, and for reopening on the same date the station in the northern Rockies. In the development of national forestry such stations are fundamental. Their function is to secure the scientific basis necessary for the growing and protection of timber, alike on public and private lands. They can do this in the cheapest, quickest, most effective, and most authoritative way, for

they substitute systematic, well-directed research as a means of solving the problems of forest management, in place of slow progress by the method of trial and error. Hardly less will be their value as demonstration areas illustrating successful methods of timber growing.

We must know how to grow timber. Our industrial requirements are at least one-third those of the entire world, excluding fuel wood. Through forestry we must make up the present deficit between an annual drain of 26,000,000,000 cubic feet and a growth of 6,000,-000,000. Reforestation of some 81,000,000 acres of devastated land is urgent; and so is application of methods of cutting which will insure continuous and full forest production on the rest of our timberlands, whether virgin or cut-over.

These things are impossible without better knowledge. The most effective methods of protection, particularly from fire, must be worked out. Growth and yields must be accurately known in order to regulate the cut rightly and afford owners a basis for a sound financial policy. Each species must be studied, as well as the natural laws governing tree growth, distribution, forest types, site values, climatic effects; in short, all that determines what can be produced on a given area, in what time, and at what cost. These in brief are the matters with which forest experiment stations are concerned. Their work is just as basic to successful forest production in the United States as is the work of agricultural experiment stations to better farming.

During the year three forest experiment stations were maintained, in Arizona, Colorado, and Washington, respectively, but each with only a one-man technical staff. Some progress was made in investigating such important subjects as brush disposal, natural reproduction, and nursery practice in the northern Rocky Mountain forests, methods of cutting in the Douglas fir and Engelmann spruce types of the central Rockies, methods of cutting, brush disposal, and regulation of sheep grazing in the western yellow pine forests of the Southwest, nursery practice and methods of planting in the Great Basin, and various phases of fire protection in California.

The establishment of new stations in the southern pine belt and the Appalachian Mountains is most opportune. The first must deal with problems on the forest area exceeding 115,000,000 acres, on which are chiefly dependent the lumber markets of the Central and Eastern States as well as the South. While it is now too late to prevent lumber production in the South from falling within a decade to a point where it will probably no more than equal local requirements, forest research should, if enlarged to an adequate basis, aid materially in increasing later production. In the Appalachians lumber production has fallen off 60 per cent in the last 10 years, yet the country must depend primarily upon this region for its future domestic hardwood supplies, and knowledge of methods of timber growing is urgently needed even now.

One well manned and equipped forest experiment station is needed for each of the important timber regions of the United States. This would require, besides the present stations in the Appalachians, the southern pine belt, the northern Rockies, Colorado, Arizona, and the Pacific Northwest, additional ones in the Northeast, the Alleghany Mountains, the Lake States, and California. These stations would

serve a total forest area of 463,000,000 acres, only 15,000,000 acres less than the total area of improved agricultural land in the United States. To the solution of the problems of this area, which in 1918 produced forest products of an aggregate value of \$1,300,000,000, we are now devoting \$85,000 annually. This provides for work on only a few of the most important and urgent problems of certain regions.

FOREST PRODUCTS.

Research in forest products, closely coordinated with the actual practice of forestry and with forest research along other lines, is fundamental for the solution of the national timber-supply problem. This work, centered mainly at the Forest Products Laboratory at Madison, Wis., seeks, on the one hand, extension of our existing timber supplies and reduction in the quantities which it will be necessary to produce to meet our future needs, and, on the other hand, furtherance of the practice of forestry through bringing about utilization along lines that will make forestry more widely remunerative. In other words, the primary purpose is to contribute toward bringing into balance production and consumption. Without provision for attacking this side of the forest problem of the country the work of the Forest Service would be hampered and its public usefulness seriously impaired.

As much wood decays in service each year as is destroyed by forest fires. Along some lines, as, for example, the treatment of railroad ties, there has been very material progress to which the Forest Products Laboratory has made important contributions. While approximately one-third of the ties of the country are now treated, the replacements on account of decay still take 2,000,000,000 feet of timber yearly. Again, one-sixth of the total lumber cut of the country is used in boxes. Laboratory investigations show that most boxes need to be redesigned and that as a rule stronger and more serviceable shipping containers could be produced from half or three-fourths as much lumber. Faulty construction also imposes on the public an annual charge of \$110,000,000 for losses in shipment.

About one-tenth of the lumber cut is used for structural purposes where strength is a factor. The use either of unsatisfactory material or of unnecessarily large sizes results in waste. Through voluminous strength tests the laboratory is steadily developing a scientific basis for the amount and quality of timber actually needed to meet specific requirements. Large possibilities have also been shown for the use of new species for certain purposes; for example, eight instead of three species can now be satisfactorily used for hardwood distillation. Incidentally, it was found that the addition of a single cheap chemical increases the yield of wood alcohol by 50 per cent. Demonstration of the suitability of many American species for pulp and paper making, together with material contributions to the development of processes for the utilization of southern pine for both kraft and book papers, have already helped to relieve a comparatively small area and a limited number of species of the entire demand for pulpwood. These cases illustrate the ways in which forest products research work through the conservation of wood materials is a factor in solving the national timber supply problem.

An example of research which by making possible the utilization of waste material adds to the value of the forest crop and hence tends to make timber growing more profitable is afforded by the improved processes developed by the Forest Service for the conversion of southern pine sawdust into ethyl alcohol. Investigations which extend the number of woods that can be used for specific purposes may prove of the greatest value in stimulating forestry through increasing the market value of the crop. For example, the development of suitable preservative treatments should create or enlarge the market for ties of softwoods, such as the pines, and of some of the hardwoods, such as beech, birch, and maple, which now decay so quickly as to be comparatively useless for ties. Laminated or built-up wood is becoming increasingly practical, and its use may have a profound effect on the future methods of forestry by lessening the need for raising large trees. Even under present conditions the development of laminated construction will mean the profitable use of millions of feet of small material now wasted. A durable waterproof glue which will withstand all weather conditions will in itself open a great field for laminated products. The laboratory has been working intensively on such a glue during the past year, and has produced the most water-resistant glue now available.

Laboratory investigations of the future must deal more and more with second-growth materials as our virgin forests are exhausted. One investigation of the current year is designed to develop the most effective means of using the rapidly grown, knotty, second-growth pine of the Northeast for lumber and box making. Another important field for making forest-products research aid directly in the development of profitable forestry will be a systematic study of the inherent qualities and adaptability for particular uses of species which can be quickly and easily grown but now have little value. Striking examples of this sort are the extensive jack pine and aspen stands of the Lake States.

Forest-products research has also proved of great value in connection with the administration of the National Forests. Special research projects have been aimed directly at specific problems, general information has been made available on various questions, and technical advice has been supplied local wood-using industries dependent on the National Forests for material. The exact and satisfactory appraisal of National Forest timber has been greatly aided by intensive products studies of logging and milling methods and costs. In several of the western districts intensive studies of special utilization problems and also of the markets supplied partly by National Forest timber have been made; for example, of such important mining districts as Butte and Coeur d'Alene. These studies not only make it possible to meet current demands to best advantage but also serve as a partial basis for the management plans which are gradually being matured for the National Forest areas. The Forest Products Laboratory has conducted special studies to further the use of National Forest timbers; for example, the suitability of local species in Alaska for mining purposes, of southwestern species for construction purposes, and of some California species for citrus-fruit boxes were investigated. An investigation has been under way for the past year into the most effective spark arresters for locomotives,

donkeys, and logging engines, a problem of great importance because of the large number of forest fires which are the direct result of the use of unsatisfactory spark arresters. This means that the Forest Service, as it should, has in its own organization and at its command a corps of forest-products experts who have been and will continue to be used whenever they can aid in bringing about the most effective administration of the National Forests.

The most important new project undertaken by the Forest Products Laboratory during the year aimed at determining the practicability of cutting what is called "dimension stock," or the exact sizes to be used in manufacture by secondary wood-using industries direct from the log. Requirements of the secondary industries for wood in dimension stock sizes amount to 8,000,000,000 or 9,000,000,000 feet annually. Most of this material is now very wastefully cut out of standard lumber sizes after the lumber reaches the factory. It is estimated that in the furniture and wood-turning industries, which make as efficient use of their material as any of the secondary wood-using industries, 50 per cent of the lumber purchased is lost in various stages of manufacture under this system. The waste is not confined to the factories, but can be traced back to every process of transportation, seasoning, and milling, and even to logging, since small, crooked, and low-grade logs suitable for dimension stock, but not for lumber are now left in the woods.

This work has an unusual chance for success, because it is receiving the general support of both producers and consumers. The initial intensive studies are being confined to the chair and wood-turning groups, because both are of such a character as to lend themselves with comparative ease to standardization of wood stock requirements, and because in the latter group standardization work has already been carried far along by the National Association of Wood Turners. An immediate result of the study of waste in the secondary industries will be that the laboratory can bring the factories into closer touch with one another's wood requirements and can point out a market in one factory for the waste in another. In anticipation of this development the wood waste exchange established some years ago at Washington has been transferred to Madison.

FOREST ECONOMICS.

During the year State reports on the requirements of the wood-using industries in relation to forest resources were completed and are being published for New York and North Carolina in cooperation with the State authorities. A study was instituted in Michigan to determine in as exact a way as possible the economic effects of forest devastation, particularly from fires, on the various industries of the State. Some progress was made in compiling data on timber resources available for pulp manufacture in the Lake States and the Northeast, and also on timber resources of other countries with particular reference to its bearing on our own timber requirements. Statistical reports on lumber production in 1920, pulpwood consumption in 1920, and the amount of wood given preservative treatment were completed and published.

With the present discrepancy between a consumption of 26,000,000,000 cubic feet of timber annually and a growth of only 6,000,-

000,000, it is only a question of time when the country will face an acute timber shortage unless the right remedial measures are quickly found and applied. To work out the problems involved, a comprehensive timber survey is the first essential. Such a survey should, among other things, secure an inventory of the timber resources, their location, and availability for use. More accurate information is required as to the present and probable future requirements of the various wood-using industries. This must be supplemented by exact knowledge on the area of land available for forest production, on timber growth, and on the possibilities of increased yields under the practice of forestry. Only on the basis of such data can comprehensive plans to insure suitable supplies of satisfactory materials for our various requirements be formulated.

Depletion is not proceeding evenly, however. Some industries have an assured supply for some years to come, whereas in others the situation is already known to be acute. For example, handle makers, automobile manufacturers, and the vehicle and agricultural implement industries all compete actively for the remaining supplies of hickory and ash. Although the situation is serious, no one knows just what the remaining supplies are or how long they will last, and there is no basis for satisfactory plans as to supplies of raw materials for any of these industries. The same situation exists in the pulp and paper industry in the regions of its greatest concentration. The State of New York, for example, is now importing 54 per cent of the pulpwood consumed by its mills, and this mostly from Canada, where an assured future supply is seriously open to question. In Pennsylvania pulp and paper concerns are actually relogging areas cut over 20 years ago for hemlock to secure dead stubs, down logs, and even high stumps. These are merely two examples of acute timber shortages faced by special industries. Pending provision for a comprehensive timber survey much can be accomplished by securing more piece-meal information as to the amount, quality, and location of remaining supplies in comparison with present and probable future demands.

Along other economic lines there is also urgent need for information on which to base public and private policy in the development of forestry. The average length of haul for lumber and pulpwood and nearly all other forest products is rapidly increasing. Douglas fir from the Pacific coast is now going into our Atlantic coast markets, and pulpwood hauls of more than 750 miles are not uncommon. If the relationship between transportation and the costs and availability of lumber and other forest products were known in detail, both the importance and the profitableness of local timber production could be more accurately gauged.

Present forms of taxation are one of the most serious obstacles in the way of the growing of timber on privately owned lands. An annual tax is imposed on the timber crop during the entire period of its growth, which may be from 25 to 150 years or even more. A similar taxation policy for agricultural crops would lead to a tax assessment at intervals of a week or even less during the growing season. The taxation of forest land is a State function, but the States look to the Federal Government for guidance as to the best solution of the present situation. Unless the Federal Govern-

ment undertakes the investigations necessary to develop the most satisfactory methods of taxation for forest lands, the present conditions may continue for years to come. Studies of resources, transportation, and taxation merely illustrate the character of economic study which should be undertaken by the Federal Government in order to obtain the basis for a sound public policy.

RANGE INVESTIGATIONS.

Grazing investigations were severely reduced in a number of the districts to provide men for range appraisal. Other range investigations were heavily curtailed for lack of funds, although the series of droughts which have visited the entire western range country within the last three years have made the need for work of this kind greater than ever before. One of the most necessary studies is that relating to the time in the spring at which the stock should be turned upon the Forest ranges. Investigation on a few Forests where range deterioration was very marked showed conclusively that a large portion of the damage occurred through placing the stock on the ranges several weeks before the forage plants developed sufficiently to be grazed without injury to their growing capacity. It has been found on a number of Forests that the stock have been entering fully four weeks earlier than they should. Additional studies of this kind are badly needed as a basis for the fixing of proper grazing seasons which will insure maximum forage production.

Study of the distribution, forage values, and life history of the plants which make up the forage crop on the National Forest ranges was materially advanced during the year. Forest officers are making steady progress in acquiring essential knowledge of these matters. In California and Oregon the effect of burning brush areas on their grazing values was further investigated, with inconclusive results. In some cases additional vegetative growth of some value was secured, while in others the vegetation suitable for grazing was reduced. The question of erosion due to the burning off of the brush cover is a serious factor in the problem.

On the Jornada Range Reserve in New Mexico and the Santa Rita Range Reserve in Arizona the experiments in handling cattle in large numbers under purely open-range conditions are being continued with marked success. In that region the drought of several years, which was especially severe during the winter and spring of 1920-21, caused heavy losses to the live-stock interests in that region. On these reserves the average losses were from one-third to one-fifth of those on outside ranges, while calf crops were more than 50 per cent greater. As rapidly as possible the information gained through the management of these two range reserves is transmitted to the Forest officers handling the ranges on the National Forests with a view to giving the stockmen the benefit of the experiments.

The eradication of larkspur by grubbing was continued. About 15,850 acres have been practically cleared of this plant, which causes annually heavy losses to the cattle owners throughout the West. The total cost of this work to date is materially less than the annual saving to stock owners in reduced losses through larkspur poisoning on the areas cleared. With sufficient men and funds all the National

Forest ranges could be virtually cleared of larkspur within one or two seasons, and the losses, estimated at about \$500,000 each year, could be almost entirely wiped out.

INFORMATIONAL ACTIVITIES.

Mention was made in last year's report of the establishment of a Branch of Public Relations. During the past fiscal year the organization of this branch was built up in the western districts as local conditions required and available funds made possible.

The chief function of public relations in the districts is to bring about more general cooperation of the public with the Forest Service for the prevention and control of forest fires, particularly on the National Forests. This is partly to reduce the cost of fire control and direct loss to the Government through fire damage, partly to prevent needless diminution of the timber supplies necessary to meet the economic needs of the country. These ends can be attained only as the users of the National Forests, the people living in and near them, and our citizens generally can be brought to realize that forest preservation is a matter of direct interest to them and that its accomplishment calls for individual care not to cause fires.

Effective utilization of the local Forest force to diffuse a better knowledge of the services of the forests, the need of public cooperation to prevent fires, and the methods necessary to pursue in order to prevent them is one of the important objects of the district public relations organization. Local publicity, enlistment of the interest of newspaper editors and civic and commercial organizations, talks in schools, the display in public places and the posting along roads and trails of suitable cautionary warnings and appeals, and the distribution to automobilists and others entering the Forests of windshield stickers, maps, and other literature or devices which help convey the lesson of care against fire are among the means used.

Where incendiary fires are of noticeable frequency the local situation is studied to discover the reasons and steps are taken to bring about better public sentiment. It is already manifest that a material reduction of the fire risk follows well-directed effort along the above lines. Obviously, its results are cumulative; its full benefits can be realized only through a continuous process of education carried on for a series of years; and the present situation necessitates the planning of expenditures and the use of time of the Forest Service personnel with a view primarily to immediate results and demands. Until more money is available, therefore, for the administration and protection of the National Forests much less can be done to prevent fires than the best interests of the public call for.

In the Washington office the informational activities include the supply of material for the use of the press service of the department, the preparation and use of exhibit material in cooperation with the departmental office of exhibits, the preparation of plans for obtaining and using motion pictures in cooperation with the corresponding departmental office, the gathering and use of illustrative photographs, the putting into final form of all official publications, the distribution of material relating to forestry suitable for school use,

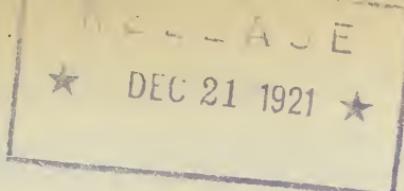
cooperation with outside agencies through which useful knowledge of our forests, their service, their protection, and their best use can advantageously be disseminated, and similar lines of work. It is impossible, however, to utilize fully the opportunities open for advancing the practice of forestry along these lines. The demands of the press and the public for information and educational material are very heavy, and increasing as the importance of forest preservation is more widely recognized.

Forty-five new publications were issued during the year. The distribution of Forest Service publications totaled 342,745 copies. About 140 addresses were made, mainly at expositions and upon request from National Forest users, lumbermen's associations and similar trade bodies, technical societies, and education institutions.





EXPERIMENT STATION FILE
DEC 13 1921



REPORT OF THE INSECTICIDE AND FUNGICIDE BOARD.

UNITED STATES DEPARTMENT OF AGRICULTURE,
INSECTICIDE AND FUNGICIDE BOARD.
Washington, D. C., September 27, 1921.

SIR: I have the honor to submit herewith the report of the work of the Insecticide and Fungicide Board for the fiscal year ended June 30, 1921.

Respectfully,

J. K. HAYWOOD.

Chairman.

Hon. HENRY C. WALLACE,
Secretary of Agriculture.

The Insecticide and Fungicide Board assists the Secretary of Agriculture in the enforcement of the insecticide act of 1910. This act was designed to prevent the manufacture, sale, or transportation of insecticides or fungicides (including disinfectants) which are below the strength claimed for them, which will not accomplish the results promised, or which fail to comply with any other provisions of the act, the purpose being to require that labels shall contain only truthful statements and that articles subject to the provisions of the act shall not be adulterated.

The products designed for use by agriculturists and stock raisers constitute the most important class which is subject to the provisions of this act. The economic situation which obtained during the past year has resulted in a curtailment of the use of these materials. This depression, which is undoubtedly only temporary in character, has given the board an opportunity to devote more attention to disinfectants and household insecticides. These classes are probably represented by materials of a more varied type than any other class of products and the labels used in connection with their sale commonly bear grossly exaggerated statements. Certain abuses have grown up in connection with the manufacture and labeling of disinfectants which it is hoped the board's activities the past year will largely reduce.

New preparations are constantly making their appearance, which requires the board to direct its activities into new channels. The necessity for the enforcement of this law is strikingly illustrated by the fact that these new preparations commonly are labeled in violation of the law and it is either necessary to prosecute the manufacturer or engage in extended correspondence, in order to secure a correction of the label, the procedure depending upon the gravity of the violation. The service rendered to the people through the enforcement of this law is becoming increasingly apparent, and the trade itself now recognizes that the law acts as a check upon the unscrupu-

lous manufacturer, and helps to prevent unfair competition, to the ultimate advantage of the industry, which is becoming of increasing economic importance.

Another important result of the enforcement of this act, and one which has not received sufficient emphasis, is that it has proved to be a potent aid in the endeavor of the department to introduce new remedies. By invoking its provisions it is possible to materially assist other bureaus of the department in the introduction of new methods of control treatment, by preventing the sale of materials which purport to be of the standard recommended by the department, but which in fact are less efficacious and sometimes positively injurious. By inspecting the material offered for sale in the localities where other bureaus are attempting to introduce new control methods, it is possible to prevent to a large degree the failure of the control treatment, which would follow from the use of materials not up to standard. The successful introduction of a new treatment would be seriously handicapped by the sale of materials which were not up to the standard contemplated for such treatment, because the consequent failure would be attributed to the method of treatment advocated and thus might prevent the adoption of a truly valuable treatment.

During the past two or three years numerous experiments made by the entomologists of the board demonstrated that naphthalene nest eggs were not effective in controlling poultry lice and mites and were injurious to fowls. As a result of this work a campaign against naphthalene nest eggs intended to be used to control poultry lice and mites was started during the fiscal year 1920 and continued during the fiscal year 1921. While an improvement has been brought about, this situation is not yet under control, and the campaign will therefore be continued.

During the fiscal year ended June 30, 1920, it was noted that a considerable number of disinfectant manufacturers were adulterating their so-called "pine oil" disinfectants and their so-called "coal tar" disinfectants with mineral oil. As a consequence a number of cases involving such adulteration were referred to the Department of Justice for prosecution. During the fiscal year 1921 an organized campaign was commenced against such adulterated pine oil disinfectants and coal tar disinfectants and is still continuing. Seizures of these adulterated articles have been made, thus preventing their sale to consumers. The manufacturers will also be prosecuted under the provisions of the insecticide act.

A campaign started during the fiscal year 1919 was continued during the fiscal years 1920 and 1921 against "insect powder" adulterated with daisy flowers and with insect flower stems. While these two forms of adulteration have been checked, they have not been entirely eliminated, and this campaign will therefore be continued, both by seizure and criminal prosecution, until the practice is entirely broken up.

The campaign against adulterated and misbranded disinfectants has been continued during the year. A considerable number of disinfectant cases have been forwarded to the courts for prosecution and others of a less flagrant character have been taken up with the manufacturers by correspondence and corrections of labels thereby

secured. The labels and literature of disinfectants in the past have contained many flagrantly false statements. As a result of the enforcement of the insecticide act, and with the aid of some of the manufacturers, the labels and literature for a large number of disinfectants have been materially improved and in many cases brought into entire conformity with law. However, there are still a considerable number of flagrantly misbranded disinfectants on the market, which will receive the attention of the board during the coming fiscal year.

The campaign designed to improve the quality and labeling of Bordeaux mixture and Bordeaux lead arsenate was continued throughout the fiscal year. As a consequence the labels for a considerable number of both of these products were brought into entire conformity with law. Also most of the manufacturers of Bordeaux lead arsenates, in which the proportions of copper and lead arsenate were incorrect, changed their formulae so as to properly balance these two active constituents. Only a few badly balanced Bordeaux lead arsenates now remain on the market. It is believed that enough field work to show that these are misbranded or adulterated, or both, under the provisions of the insecticide act, has now been obtained, or shortly will be obtained, so that action can be taken to require the delinquents to revise their formulae.

During the fiscal year special attention was given certain new proprietary insecticides and fungicides which were either flagrantly misbranded relative to claims, or which when used as directed, were very injurious to vegetation, or both. One of these products was widely advertised as being effective against peach-tree borers and apple-tree borers, whereas it was not effective against either when used as directed. Another was widely advertised as being effective against scale insects in general, cattle, and poultry mites, pear psylla, aphis, pea and onion thrips, white fly, dog fleas, and many other insects; also against many fungous diseases, whereas it was found to be ineffective against practically all of the insects and fungous diseases mentioned, when used as directed. Many complaints were received from growers who had used these materials and failed to get the results promised.

The campaign inaugurated in 1919 for the purpose of inspecting the calcium arsenate used for cotton boll weevil control, and controlling same under the provisions of the insecticide act, was continued during the fiscal years 1920 and 1921. During 1919 a considerable amount of the calcium arsenate inspected either contained enough arsenic in water soluble forms to be very injurious to cotton plants, or did not contain enough total arsenic to be effective against the boll weevil. Such adulterated or misbranded shipments were seized and thus removed from the channels of commerce, and criminal action was taken against the manufacturers under the provisions of the insecticide act. During 1920 there was considerable improvement in the quality of calcium arsenate shipped to the South for cotton boll weevil control. However, a considerable amount still contained enough water soluble arsenic to be injurious to the cotton plant, although not as much water soluble arsenic as in 1919. Some shipments also contained too little total arsenic, so that they were not fully effective in controlling the boll weevil.

During the last six months of the fiscal year ended June 30, 1921, the board inspected 1,759,637 pounds of calcium arsenate, most of which had been shipped to the South during the latter part of the calendar year 1920. This was found, on the whole, to be superior to the calcium arsenate inspected during the fiscal year ended June 30, 1920. It appears, therefore, that while it will be necessary for several years to continue to carefully inspect the calcium arsenate used for cotton boll weevil control, it will not be necessary to devote so much time to the inspection of this insecticide as in the past, since most of the manufacturers appear now to be producing a product which contains the required amount of total arsenic oxid and does not contain enough arsenic in water soluble forms to be markedly injurious, except in isolated cases.

INTERSTATE SAMPLES.

During the fiscal year the board reported to the solicitor of the department 143 cases presenting alleged violations of law, with recommendation that the facts be transmitted to the Attorney General to institute criminal action or seizure proceedings. Disposition was made of 124 cases by correspondence with the manufacturers. These cases presented violations which were technical only, not flagrant or cases in which the manufacturer gave reasonable and adequate explanation of his failure to conform to the provisions of the act. Action was taken to place in abeyance 415 samples, which, upon examination and test, were shown to be in compliance with the provisions of the law or were from shipments of the same goods made prior to shipments for which the manufacturer had been convicted and had, after citation, conformed to the requirements of the law. On June 30, 1921, 72 cases were pending preliminary hearings or before the board for final action, 291 were held in temporary abeyance, pending the receipt of further information or the outcome of prosecution based on the same product or correspondence with the manufacturers, and 501 samples were undergoing analysis and test.

The inspectors and sample collectors of the board, operating throughout the United States, collected 820 samples during the year. A general classification of the articles represented in the collection is as follows:

Interstate samples collected.

Class of samples.	Number of samples.	Class of samples.	Number of samples.
Arsenate of calcium.....	98	Insecticide and fungicide preparations, agricultural use.....	56
Arsenate of lead.....	79	Kerosene emulsions.....	2
Bordeaux mixture and combinations of Bordeaux mixture with insecticides.....	73	Lice and mite killers.....	57
Chlorinated lime.....	22	Lime-sulphur solution and sulphur preparations.....	50
Dir's for animals.....	26	Nicotine preparations.....	7
Disinfectants, germicides, bactericides.....	102	Paris green.....	28
Fly preparations for animals.....	30	Pyrethrum and hellebore powders.....	17
Fish-oil and whale-oil preparations.....	6	Miscellaneous.....	51
Formaldehyde preparations.....	15		
Insect preparations, household use.....	101		

IMPORT SAMPLES.

During the year 51 official and unofficial import samples of insecticides and fungicides were collected through the various port laboratories of the Bureau of Chemistry for examination and test by the board. Disposition was made of 61 samples; 12 official samples were found adulterated and misbranded, and it was recommended that the consignments be refused entry until correctly labeled. The remaining samples were unofficial, three of them being found to be adulterated or misbranded, or both, and in these cases it was recommended that future shipments be detained, while 46 were neither adulterated nor misbranded.

SPECIAL INVESTIGATIONS.

During the year the studies of the preparation, composition, and properties of certain arsenates of calcium were continued. The work on one paper entitled "The Arsenates of Calcium—II Equilibrium in the System Arsenic Pentoxide, Calcium Oxide and Water at 35° (Basic Section)" has been nearly completed, and this paper will soon be offered for publication. This covers the region in which there is free lime and practically no arsenic oxid in solution and is consequently of interest in relation to commercial calcium arsenates. The work on another paper entitled "The Arsenates of Calcium—III—General—Preparation and Properties of the Crystallized Salts" has been completed, except for minor details, and this paper will soon be offered for publication. The paper will describe in detail the preparation and chemical, optical and crystallographic properties of about 12 definite calcium arsenates, several of which are new.

Little progress has been made during the year in the investigation started several years ago, which has for its purpose the development of a more accurate method for determining the total alkaloids in powdered hellebore root and determining reasonable standards for same, more especially limits for the sand content. The chemists who were employed to continue this line of work resigned from the department before making any considerable progress. However, the work will be continued as soon as it is possible to obtain a chemist with the requisite training.

By reason of the fact that it has been claimed that dry powdered commercial calcium arsenate containing other calcium compounds suffers decomposition on standing in the package, with the result that arsenic in water soluble forms is set free, a study of this matter was started during the fiscal year ended June 30, 1920, and continued during the fiscal year 1921. The work will also be continued during part of the fiscal year 1922. The results so far obtained show only slight changes in the stored calcium arsenate. There is definitely a slow absorption of carbon dioxid from the air, most pronounced in the loosest containers and parallel with it a slight increase in arsenic in water soluble forms.

The study inaugurated some years ago to determine the rate of loss of nicotine in potash-nicotine and soda-nicotine soaps and in papers impregnated with nicotine and to determine the effect of different types of containers on the rate of nicotine loss, the conditions under

which loss does and does not occur and the conditions that will prevent loss, has been continued during the fiscal year 1921. The chemical work on this subject is about completed and the results will soon be collated and studied and probably offered for publication.

During the year a paper was prepared by the microscopist of the Board and published in the Journal of the American Pharmaceutical Association, Volume X, No. 5, May, 1921, under the title "The Application of Optical Methods to the Examination of Insecticides and Fungicides." In the paper attention has been called to the application of optical crystallographic methods for the identification of crystallizable chemical salts in insecticides and fungicides. The author has found the use of such methods of value in many instances and has outlined a simple method of procedure particularly suitable for microanalysts who have not had extensive training in crystallography and mineralogy.

During the fiscal year the bacteriologist of the board and one of the chemists completed the laboratory work on, and prepared a paper entitled "Disinfectant Action of Pine Oil and Pine Distillation Product Emulsions and Method of Their Production and Chemical Properties." This paper will be shortly published as a Department Bulletin. It gives scientific data that are of value in detecting adulteration of commercial "pine-oil disinfectants" and in protecting the public against false claims on "pine-oil disinfectant" labels.

During the fiscal year 1921 it was found that nitrates and nitrites which are frequently present in commercial samples of lead arsenates and calcium arsenates in determinable amounts, interfere with the determination of total arsenic in these insecticides by the official method of the Association of Official Agricultural Chemists, resulting in a low figure for total arsenic, the amount of the shortage depending on time elapsing before titrating the distillate. It was found that this action could be prevented by the use of a modification of a method previously described by Jannasch and Seidel, using sodium bromide and hydrazine sulphate in the distillation flask as reducing substances. Work on this subject has been nearly completed and the results will soon be published under the title "Errors Caused by Nitrates and Nitrites in the Distillation Method for the Determination of Arsenic and a Method for Their Elimination."

Investigations by the plant pathologists of the board to determine the necessary amount of active ingredients for the control of various fungous diseases in the case of the more important types of fungicides, have been conducted on a very extensive scale, and some very conclusive data have been amassed which are of great assistance to the board in enabling it to determine from chemical analysis those fungicides which are weak or inefficient. Sufficient data along this line have been accumulated to enable the board in some special instances to require that the strength of certain weak fungicides be increased.

The work relative to the compatibility of various fungicides and insecticides used as combination sprays, both to determine the effect of such combinations relative to the injury to vegetation and their fungicidal value, was continued and more valuable data obtained.

During the year the entomologists of the board have continued their field tests and experiments with commercial calcium arsenate

to ascertain the effect of this material on the foliage of fruit and shade trees, ornamental shrubs and truck crops, both when used as a dust and as a spray in combination with standard liquid insecticides.

The Bordeaux-lead arsenate mixtures have been studied and experiments made to determine the maximum amounts of lead arsenate that can be used with the Bordeaux without causing injury to the various types of foliage.

Special attention has been given to proprietary insecticides for use against the common red mite attacking poultry and a large amount of data obtained; this material is about ready for publication.

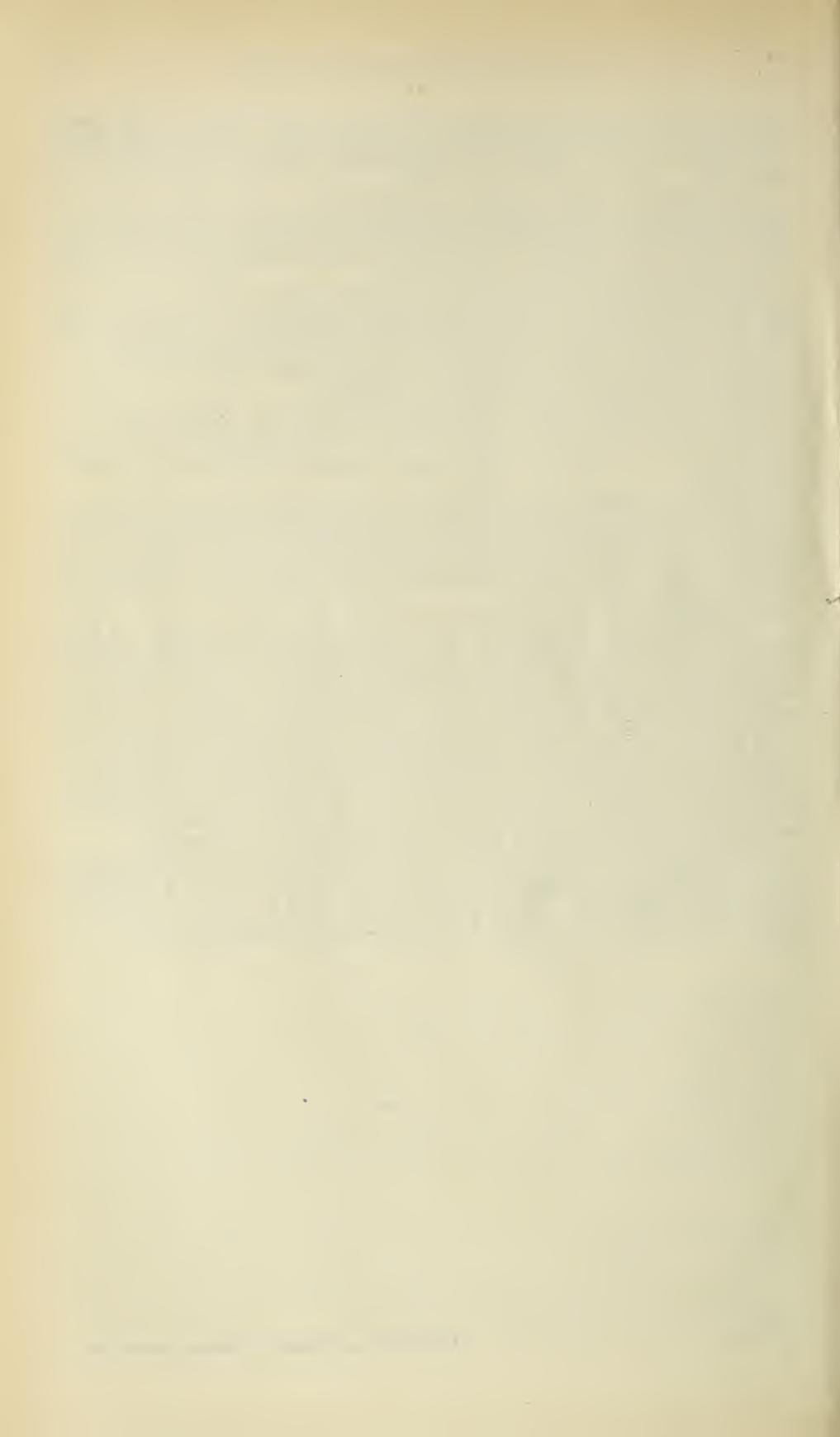
The studies of dry substitutes for liquid lime sulphur have been continued and much valuable data obtained.

The use as insecticides of sodium and calcium hypochlorites in solution has been carefully studied, and these materials in a number of different strengths have been tested against representative series of insects.

The entomologists have, in so far as their regular duties permitted, inspected and studied orchards and truck crops that have been treated by the owners with proprietary insecticides and have thereby obtained evidence that is of considerable value in the work of enforcing the insecticide act.

The scientists of the Bureau of Animal Industry branch of the board, working in cooperation with the zoological division of that bureau, have completed an investigation relative to the effect of carbon bisulphide and carbon tetrachloride as a remedy for bots and worms infesting horses. This work has been made the subject of a paper now in course of preparation for publication in one of the veterinary journals. An investigation into the value of various ingredients of insecticides claimed to be efficacious in the treatment of bots and worms in horses and worms in other animals, as well as various other parasites which infest them, is in progress.

Further work is being done on the efficacy of various preparations in the treatment of mange and in the development of a treatment for mange, especially dermodectic mange, which will be effective against this and other forms of the disease which affect canines.



LIBRARY OF THE
UNITED STATES RELATIONS SERVICE
EXPERIMENT STATION FILE
DEC 13 1921

RELEASE
DEC 10 1921

REPORT OF THE LIBRARIAN.

UNITED STATES DEPARTMENT OF AGRICULTURE,
OFFICE OF THE LIBRARIAN,
Washington, D. C., October 10, 1921.

SIR: I have the honor to submit herewith the executive report of the Library for the fiscal year ended June 30, 1921.

Respectfully,

Hon. HENRY C. WALLACE,
Secretary of Agriculture.

CLARIBEL R. BARNETT,
Librarian.

The department library consists of the main library and the branch libraries in the bureaus and offices. The work of the main library is divided into the following main divisions: (1) Readers' division; (2) catalogue and order division; (3) periodical division; (4) binding division; (5) bookkeeping, correspondence, and mailing lists. Brief summaries of the reports of these various divisions and of the reports of the branch libraries, as prepared by those in charge, are given in the following pages, followed by general statements on the work as a whole and on the needs of the library.

READERS' DIVISION.

Miss HELEN M. THOMPSON, *Chief.*
Miss GERTRUDE E. UPTON, *in Charge of Loan Desk.*

The Readers' Division has to do with all work connected with the use of the books by readers. It is divided into two main sections, (1) the reference work, and (2) the circulation work. The reference work consists in answering questions and preparing and verifying bibliographical lists in response to inquiries received in person, by letter, and by telephone from department workers or people outside of the department. Many of the questions require extended research and a wide knowledge of scientific and technical literature. The loan desk or circulation desk performs the work connected with the circulation of books and keeps the records of all books borrowed from the library by individuals, offices, and other libraries, and of all books lent to this library by other libraries.

The name, Readers' Division, is a new title which was adopted at the beginning of this fiscal year in place of the former "Reference and Circulation Division." At the same time the Chief of the Catalogue and Order Division was made Chief of the Readers' Division, and the assistant librarian, who had previously had charge of the Reference and Circulation Division, took immediate charge of the Catalogue and Order Division, while retaining general supervision of the reference work. It seemed desirable to make this change for a year in order that the Chief of the Catalogue Division might acquire a more intimate knowledge of the needs of readers and of the questions which the catalogue was called upon to answer. The reference and bibliographical work of the library has been seriously handicapped during the past year by lack of assistance, it not having been possible on account of lack of funds, to fill the position of reference librarian which became vacant in March, 1919.

In the early spring of 1921 a change was made in the reference and reading rooms. The wall which separated these rooms from the stack room on the first floor was removed and the locations of the cases for the reference books were changed. There is now direct access to the reference rooms from the corridor of the building instead of through the end of the stack room. This has much improved the appearance of the library and has given somewhat better supervision of readers as well as some additional light for the readers' tables. Unfortunately, however, the close proximity of other buildings to the building in which the library is located still makes it necessary for the reading rooms to depend upon artificial light the greater part of the day. In addition to the changes made in the reference room, the library acquired another stack room of approximately 400 square feet in the basement adjoining the folio room. The room was fitted up with 33 double face sections of standard steel shelving and 15 single face wooden sections, giving the library about 1,200 linear feet of additional shelving. This shelving has made it possible to relieve to some extent the crowded condition of the shelves.

In connection with the following statistics of circulation it is necessary to explain that they show only approximately the use of the library, as circulation statistics are not kept in all of the branch libraries in the bureaus and offices. Furthermore, no statistics of the reference use of the library are kept either in the main library or in the branch libraries.

STATISTICS OF CIRCULATION.

Bureau, division, or office.	Number of books charged.								Number of periodicals charged.	
	To individuals.		To main library.		To branch libraries.		Total.			
	1920	1921	1920	1921	1920	1921	1920	1921	1920	1921
Main library ¹	11,938	11,775	.....	.....	26,363	29,065	38,301	40,841	.....	.....
Bureau of Animal Industry.....	(1)	4,404	(1)	188	(1)	.....	(1)	4,592	(1)	54,259
Bureau of Chemistry.....	7,567	7,955	481	591	13	65	8,061	8,611	18,792	24,562
Bureau of Crop Estimates.....	7,695	9,260	752	979	237	346	8,684	10,585	15,000	10,000
Bureau of Entomology.....	2,365	2,259	213	264	123	134	2,701	2,657	3,032	2,630
Office of Farm Management.....	2,929	3,145	.....	.....	.....	.....	2,929	3,145	9,972	11,138
Forest Service.....	2,901	2,729	277	420	.....	1	3,178	3,150	7,965	7,740
Bureau of Markets.....	.....	.....	.....	.....	.....	.....	4,213	5,067	(1)	(1)
Bureau of Plant Industry.....	9,208	12,186	330	374	40	34	9,578	12,610	39,955	54,171
Bureau of Public Roads.....	703	944	137	80	6	12	846	1,037	6,977	9,169
	45,306	54,657	2,190	2,896	26,782	29,658	78,491	92,115	101,696	173,672

¹ Figures not available.

The statistics of circulation given in the preceding table show that the total recorded circulation of the main library and the bureau and office libraries for the year was 92,115 books and pamphlets and approximately 173,000 current periodicals. No satisfactory comparison between the total circulation this year and last year can be made, since some of the bureau and division libraries which kept statistics last year have not kept them this year, and vice versa. The fact, nevertheless, that the number of books charged at the loan desk of the main library last year shows an increase over the previous year and that there was also an increase last year over the fiscal year

1919 indicates an increase in the use of the library as a whole and a gradual recovery in the scientific work of the department from wartime conditions. The circulation has not, however, reached as yet its prewar figures, as is shown by the following table, which gives the circulation statistics of the main library by months and years for the last 10 fiscal years, exclusive of the circulation of current periodicals.

Circulation statistics of the main library, by months and years, for the fiscal years 1912 to 1921.

Month.	1911-12	1912-13	1913-14	1914-15	1915-16	1916-17	1917-18	1918-19	1919-20	1920-21
July.....	2,397	2,472	2,651	3,019	3,077	2,932	3,113	2,860	2,687	2,827
August.....	2,425	2,269	2,083	2,567	3,285	2,883	3,027	2,616	3,216	2,867
September.....	2,517	2,584	2,531	2,793	3,334	2,955	2,968	2,232	2,678	2,790
October.....	3,404	3,048	3,301	3,903	4,183	4,421	3,617	2,474	3,444	3,101
November.....	3,465	3,152	3,232	3,352	4,439	4,409	3,462	2,684	2,981	3,381
December.....	2,962	3,051	3,226	3,570	4,140	3,797	3,137	2,723	2,897	3,369
January.....	4,094	4,106	4,454	4,290	4,888	4,839	4,099	3,572	3,668	3,932
February.....	3,851	3,403	3,618	3,638	4,715	4,625	3,603	3,830	3,346	3,481
March.....	3,614	3,415	4,021	3,930	5,028	4,640	3,876	3,920	3,690	3,840
April.....	3,415	3,394	3,623	3,514	4,052	3,766	3,444	3,608	3,497	4,444
May.....	3,208	3,148	2,951	3,072	4,136	3,616	3,531	3,327	3,103	3,326
June.....	2,760	2,891	3,188	3,285	3,637	3,476	2,770	2,606	3,085	3,483
Year.....	38,112	36,933	38,879	40,953	48,914	46,339	40,447	36,457	38,301	40,841

INTERLIBRARY LOANS.

The number of books lent to libraries, institutions, and individuals outside of the city was 1,139, an increase of 340 as compared with the previous year. To the total number of books lent should be added 78 photostat copies and 11 typewritten copies of articles requested, making the total use outside of the city 1,228. The statistics of the last five years, arranged alphabetically by States, are as follows:

Record of books lent outside of Washington during the fiscal years 1917 to 1921.

States, etc.	Fiscal year—					States, etc.	Fiscal year—				
	1917	1918	1919	1920	1921		1917	1918	1919	1920	1921
Alabama.....	10	.....	10	17	5	North Dakota.....	3	6	6	5	14
Arizona.....	7	4	4	23	.....	Ohio.....	41	56	9	30	32
Arkansas.....	4	5	9	19	32	Oklahoma.....	.....	.....	.....	1	7
California.....	38	13	28	43	16	Oregon.....	51	73	5	19	53
Colorado.....	16	7	5	10	18	Pennsylvania.....	19	21	10	30	51
Connecticut.....	2	5	1	7	13	Rhode Island.....	17	4	2	12	5
Delaware.....	6	17	11	30	21	South Carolina.....	27	14	2	2	12
Florida.....	15	21	17	7	5	South Dakota.....	.....	.....	3	.....	.....
Georgia.....	24	5	4	6	12	Tennessee.....	22	19	11	10	11
Idaho.....	10	6	4	8	1	Texas.....	38	8	9	4	21
Illinois.....	30	44	49	23	20	Utah.....	16	8	8	14	19
Indiana.....	13	11	4	13	38	Vermont.....	3	3	10	3	7
Iowa.....	40	52	15	22	72	Virginia.....	18	4	10	19	46
Kansas.....	38	31	41	22	3	Washington.....	2	8	21	12	31
Kentucky.....	4	8	13	15	13	West Virginia.....	8	19	19	10	13
Louisiana.....	8	21	9	5	5	Wisconsin.....	34	36	62	2	48
Maine.....	16	10	2	3	1	Wyoming.....	3	.....	6	4	6
Maryland.....	48	30	10	21	24	Canada.....	1	1	3	1	2
Massachusetts.....	33	22	10	37	16	Hawaii.....	3	2	1	.....	.....
Michigan.....	38	21	9	17	50	Porto Rico.....	39	28	11	14	32
Minnesota.....	50	44	63	89	88	Island of Guam.....	.....	2	1	.....	.....
Mississippi.....	1	1	1	.....	4	Alaska.....	.....	.....	1	.....	1
Missouri.....	19	6	2	10	6	Panama.....	.....	.....	.....	.....	1
Montana.....	19	37	17	13	7	Total.....	1,093	893	658	799	1,139
Nebraska.....	10	4	.....	15	7	Photostat copies of articles.....	168	84	145	142	78
Nevada.....	1	1	1	.....	.....	Typewritten copies of articles.....	12	11	.....	17	11
New Hampshire.....	8	10	7	6	9						
New Jersey.....	76	28	42	49	89						
New Mexico.....	8	6	7	6	11						
New York.....	148	103	66	85	81						
North Carolina.....	15	7	1	6	26						
						1,273	988	803	958	1,228	

The library has likewise been the recipient of many favors in the matter of interlibrary loans from university and reference libraries in Boston, New York, Baltimore, Philadelphia, Cincinnati, Chicago, St. Louis, and other cities, in addition to those from the Library of Congress and other Government libraries. A summary of the statistics regarding books borrowed from libraries in and out of Washington during the past 10 years is given in the following table. It shows that the number borrowed in the past two years is about two-thirds of the number borrowed in 1916 and 1917.

Summarized statement of books borrowed from other libraries during the fiscal years 1912 to 1921.

Library from which borrowed.	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921
Library of Congress.....	(1) 3,000	3,868	4,367	5,279	4,629	3,567	4,126	3,355	3,290	
Surgeon General's library.....	(1) 1,056	805	750	939	962	878	607	476	470	
Smithsonian Institution and National Museum.....	(1) 138	205	130	227	141	124	110	75	100	
Geological Survey library.....	(1) 62	137	101	92	57	49	64	73	61	
Bureau of Education library.....	(1) 29	31	15	43	41	4	11	4	21	
Patent Office library.....	(1) 15	21	19	29	49	25	36	18	20	
Other libraries in Washington.....	(1) 1,377	99	81	163	131	70	72	129	115	
Total from libraries in Washington.....	6,344	5,677	5,166	5,463	6,774	6,010	4,717	5,026	4,160	4,077
Libraries outside of Washington.....	61	91	62	58	86	82	35	70	39	58
Grand total borrowed from all libraries.....	6,405	5,968	5,228	5,521	6,860	6,092	4,752	5,096	4,199	4,135
Largest number borrowed on any day.....	(1) 43	40	42	42	41	46	41	30	60	
Average number borrowed daily.....	(1) 18	16	18	23	16	15	16	13	13	
Largest number borrowed in any month.....	(1) 731	564	579	734	623	481	613	458	480	
Average number borrowed monthly.....	(1) 480	432	460	571	507	396	424	346	344	

¹ Separate statistics not available.

CATALOGUE AND ORDER DIVISION.

Miss EMMA B. HAWKS, *Assistant Librarian*, in Charge.

The total number of catalogued books, pamphlets, and maps added to the library during the year was 7,485, a decrease of 2,108 as compared with the catalogued accessions of the previous year. This decrease was due in part to a decrease of about \$2,400 in the amount available for the purchase of books and periodicals, it having been necessary to spend that amount for additional shelving, and in part to lack of assistance. Detailed statistics of the accessions of the past five years are given in the following table:

Accessions.	1917	1918	1919	1920	1921
Purchases:					
Volumes.....	1,949	1,510	1,373	1,989	1,420
Pamphlets.....	76	79	88	119	47
Maps and charts.....	1	4	2	6	3
Serials and continuations.....	147	97	154	187	456
Total.....	2,168	1,690	1,617	2,301	1,926
Gifts:					
Volumes.....	641	676	647	768	774
Pamphlets.....	508	642	371	580	492
Maps and charts.....	4	59	15	21	10
Continuations.....	4,458	3,807	2,647	4,762	3,515
Total.....	5,611	5,184	3,680	6,131	4,791
From binding periodicals and serials.....	1,178	949	748	1,161	768
Total.....	8,957	7,823	6,045	9,593	7,485

According to the record of accessions, the total number of books and pamphlets accessioned by the library up to July 1, 1920, was 165,593. From this number should be taken 5,910 volumes which were discarded during the fiscal year 1915 and 701 volumes which were discarded in the last six fiscal years, leaving a balance of 158,982.

Since the funds available for the purchase of books during the past year was much smaller than in the previous year, the number of notable purchases was less, but a few valuable desiderata were obtained, among which should be mentioned the following:

VALUABLE ACCESSIONS.

Duchesne, Antoine Nicolas. *Histoire naturelle des fraisiers.* 1766.
 Florinus. *Oeconomus prudens et legalis; oder allgemeiner kluger und rechts-verständiger Hauss-Vatter.* Nürnberg, 1722.
 Gautier d'Agoty, J. *Collection des plantes usuelles, curieuses et étrangères.* 1767.
 Gerard, John. *Catalogus arborum, fruticetum ac plantarum tam indigenarum, quem exoticarum, in horto J. Gerardi . . . nascentium.* (2d ed.) Londini, 1599.
 Gilii, Filippo Luigi, and Xuarez, Caspar. *Osservazioni fitologiche sopra alcune piante esotiche introdotte in Roma.* 3 fasc. in 1. 1789-92.
 Gould, John. *Icones avium.* 2 fasc. 1837-38.
 Gould, John. *Birds of Australia and the adjacent islands.* 2 fasc. 1837-38.
 Hernández, Francisco. *Opera.* 3 v. 1790.
 Jaume St.-Hilaire. *Plantes de la France, décrites et peintes d'après nature.* 10 v. 1819-22.
 Langley, Batty. *New principles of gardening.* 1728.
 Palisot de Beauvois. *Flore d'Oware et de Benin en Afrique.* 2 v. 1804-07.

Among the periodical sets completed were the *Allgemeine Gartenzeitung* and the *Florist and Garden Miscellany*. Through the courtesy of the New York Society Library, a photostat copy of the rare book entitled "Quatre traictez utiles et delectables de l'agriculture, Paris, 1560," was obtained.

Mention should also be made here of the continued generosity of institutions, societies, and friends of the library from whom a large number of valuable volumes, pamphlets, and reprints have been received as gifts. It is regretted that lack of space forbids enumerating the donors.

CATALOGUING AND CLASSIFICATION.

The record of the material catalogued and classified during the year is as follows: 2,194 volumes, 539 pamphlets, 13 maps, and 3,971 serials and works published in parts, making a total of 7,485, a decrease of 2,108 as compared with the previous year. In addition to the complete cataloguing of the above-mentioned items, author cards were made for 96 pamphlets of less importance, and 4,828 reprints. There were added to the main dictionary catalogue 23,730 cards and 4,244 were withdrawn, making a net addition of 19,506, an increase of 355 as compared with the previous year. The main catalogue now contains approximately 450,000 cards.

The number of titles prepared during the year for printing by the Library of Congress in what is known as the "Agr." series are as follows: Cards for accessions, 1,097; cards for department publications, 627; total, 1,724, an increase of 286 over the previous year. The total number of titles prepared by the library since 1902, in which year the printing of the cards was begun, now amounts to 34,692.

The amount of uncatalogued material on hand July 1, 1921, was as follows: 290 volumes, 1,085 pamphlets, and 1,105 continuations, a total of 2,480 pieces, which is an increase of 1,060 over the previous year. This large decrease in the output of the Catalogue Division was due to the fact that the work has been seriously hampered by the loss during the year of four of the cataloguing force and the necessity of employing a number of temporary assistants.

PERIODICAL DIVISION.

Miss LYDIA K. WILKINS, *Chief*.

The total number of different periodicals, exclusive of annuals and serials of infrequent issue, received currently during the year was 2,999, of which 644 were received by purchase and 2,355 by gift. The number of new periodicals added during the year was 301, whereas 59 of those listed last year were no longer received, either because they have ceased publication permanently or temporarily, or because the subscriptions have been discontinued. The net increase for the year was 242. In order to meet the demands for certain periodicals it was necessary to purchase 261 duplicates, making the total number of periodicals purchased 905, a net increase of 58 over the previous year. The library also received 649 duplicates by gift and exchange, making the total number of periodicals handled currently during the year 3,909, a net increase of 362 for the year. A record of the current periodicals, which was kept for the months of May and June showed that the average number received daily was 268.

A list of the periodicals and other serials currently received by the library, which was prepared for publication in June, is now in press. The list is arranged alphabetically and there is also a subject index and a geographical index of foreign periodicals.

In addition to the 2,999 current periodicals appearing not less than four times a year, the library received 3,849 serials of less frequent issue, such as annual reports, proceedings, and transactions published by institutions and societies. More than nine-tenths of these were received by gift and exchange. The large number of periodicals and other serials received by gift and exchange is most gratifying, especially on account of the limited funds of the library. Through the courtesy of publishers, especially of agricultural papers for which a subscription is rarely asked, the greater number of the American periodicals are received gratis. In addition, a large number of foreign periodicals and publications of Government offices, institutions, and societies are received in exchange for publications of the department. The receipt, stamping, recording, circulating, filing, and binding of the thousands of separate numbers received constitutes an important branch of the library's work.

DUPLICATES.

As in previous years, it was necessary to spend considerable time in disposing of the duplicates received by the library. They are for the most part periodicals, official publications, and publications of societies and institutions which are sent to various offices of the department and later turned over to the library. During the year

the number of duplicates listed and disposed of filled 30 mail sacks, exclusive of a large number of official State and Federal publications which were returned to the issuing offices without listing. There is urgent need of an additional assistant whose full time can be devoted to this work of listing and disposing of the duplicates, in order to keep the work up to date, especially as the space available for storage is limited.

BINDING.

Miss EDITH ENDICOTT, *Chief.*

During the year 1,821 volumes were sent to the bindery. In addition to the number of books permanently bound, 1,152 periodicals were laced in temporary binders, and 622 pamphlets stapled in pamphlet binders. Approximately 3,000 current numbers of periodicals, bulletins, and reports were also added to files already in binders. These consisted principally of department and State experiment station publications, the files of which are placed in temporary binders until a sufficient number has been received for permanent binding.

In the middle of November, the former chief of the bindery division resigned and it was necessary for her successor, who had had no experience in binding and no previous experience in this library, to take up the work after only a week's instruction under the former chief. It was therefore especially gratifying that in spite of these difficulties and handicaps, the number of books bound was only slightly less than in the previous year. Like other divisions of the library, the binding division is in need of additional assistance, as it is impossible to keep the work up to date with the present force. Scientific literature is largely published in serial and pamphlet form and in paper-bound volumes. The large number of publications received by the library in this form calls for the binding annually of more than double the number of volumes which it has been possible to bind in the past few years.

BUREAU AND OFFICE LIBRARIES.

In the following list are enumerated the various branch libraries in the bureaus and offices. The statistics, summaries, and extracts which are given in regard to the various libraries are taken from the reports of the librarians. It is regretted that it is impossible from lack of space to give these reports in full. An account of the bibliographical work of the various libraries is given under the heading "Bibliography." Statistics of circulation are given in the table "Use of the library" on page 2.

Books, pamphlets, and periodicals in bureau, division, and office libraries.¹

Bureau or office.	Librarian in charge.	Number employed.	Number of books.	Number of pamphlets.	Number of periodicals currently received.	Number of registered borrowers.	Number of registered borrowers to whom periodicals are circulated.
Bureau of Animal Industry.	Miss Carrie B. Sherfy, librarian. Miss Florence M. Thompson, associate librarian. Miss Jessie Urner.	3 2 2	2,600 2 4,600 18,000	2,650 490 157	490 244 35	120	112
Animal Husbandry Division.							.....
Bureau of Chemistry.	Miss Louise Duvall.	4	2 7,700	.....	415	244	101
Bureau of Crop Estimates.	Mrs. E. H. Painter.	2	2 18,000	.....	698	.....	16
Bureau of Entomology.	Miss Mabel Colcord.	2	7,667	9,325	345	121	17
Office of Farm Management.	Miss Anna Dewees.	3	.....	.....	242	94	50
Forest Service.	Miss Helen M. Stockbridge	1	2 22,469	.....	88	133	.....
Bureau of Markets.	Miss Mary G. Lazy.	7	4,192	.....	695	.....	.....
Bureau of Plant Industry.	Miss Eunice R. Oberly.	10	2 4,000	2 1,000	910	411	145
Bureau of Public Roads.	Miss Orrena L. Evans.	1	1,150	4,450	215	135	50
States Relations Service	Miss Martha L. Gericke.	8	2 2,900	2 8,000	796	113	.....

¹ All books for the use of the department in Washington, including those filed in the bureaus, are purchased and catalogued by the main library. No bureau libraries are maintained by the Bureau of Soils and Biological Survey. The Weather Bureau library is administered separately, with the exception that the books and periodicals are purchased from the appropriation for the library of the department, the sum of \$1,000 being set aside each year for this purpose. The report of the Weather Bureau library is contained in the report of the Weather Bureau.

² Approximate figures.

³ Books and pamphlets.

In the report for last year reference was made to the reorganization of library activities of the Bureau of Animal Industry, authority having been given in February, 1920, for merging the Dairy Division library with the library work of the other offices of the bureau, with the exception of the Animal Husbandry Division which is in the office of the division some distance from the main office and laboratories of the bureau. On account of lack of space it was not possible, however, for some months, actually to consolidate the work, part of which was conducted on the second floor and part on the fourth floor of laboratory A. On December 20 a room adjoining the library quarters on the second floor was provided, making it possible to bring together in one place the collections and library work of the bureau, with the exception, as stated, of that of the Animal Husbandry Division. As a result of the reorganization the library work of the bureau is carried on with greater efficiency. During the year about 1,800 cards were added to the index to veterinary literature and 400 cards were added to the index to dairy literature. The index to veterinary literature is a comprehensive index which now contains about 182,000 cards. The dairy index is much smaller and included only the recent and more important literature.

A change in the location of the library of the Animal Husbandry Division of the Bureau of Animal Industry also took place during the year, the division having been moved from the Busch Building, 710 E Street NW., to the second floor of one of the wings of Building F, Mall group, a building erected during the war for use by the War and Navy Departments. A larger room has been furnished for the use of the library, with considerable improvement in the lighting facilities.

During the year an additional clerk was assigned to the library to assist in maintaining the photographic files and to take care of the routine work connected with the periodicals.

The Bureau of Biological Survey does not this year appear in the list, as the bureau, which is in the same building with the main library, no longer maintains a bureau collection, the books being charged directly to the men who wish to use them.

Since the reorganization of the Office of Farm Management in 1918, the scope of the work of the office has materially changed. The name of the office on July 1 became Office of Farm Management and Farm Economics. Increasing emphasis is now placed upon economic problems and agricultural history. The changes in the work of the office made it important during the year to formulate a policy for the future development of the library which would enable it to meet the needs created by these changes. As the position of librarian of the office which was made vacant by the resignation of Miss Cora L. Feldknap on July 1, 1920, had not been filled, Mr. Oscar C. Stine of the office was asked by the chief, Dr. H. C. Taylor, to work out a policy for the library in cooperation with the librarian of the department. As a part of the plan of reorganization, Miss Anna Dewees was appointed by the office on April 1, 1921, as library assistant, and detailed to the main Library for part-time work for three months in order to become familiar with the work of the main library preparatory to taking up the duties of librarian of the Office of Farm Management and Farm Economics on July 1, 1921. During the month of June changes were made in the arrangement of filing cases, desks, and book cases in order to provide more space for reading and reference tables. A large number of official agricultural publications which were no longer needed in the office were returned to the offices which issued them and a number of books were returned to the main library. At the close of the fiscal year, before the reorganization of the library was completed, the plans announced by the department for the future consolidation of the Office of Farm Management and Farm Economics with the Bureau of Markets and Crop Estimates, if approved by Congress, seemed to indicate that the ultimate library plans for the Office of Farm Management and Farm Economics were still to be determined.

The work of the Bureau of Markets library was changed at the beginning of the fiscal year by the entire separation of the library from the editorial work. Miss Caroline B. Sherman, librarian and editor of the bureau from its organization to that date, was transferred to the Division of Market Information of the bureau, in order that she might give her full time to the editorial work. She continued to act as librarian, however, until August 1, when Miss Mary G. Lacy took charge. Aside from the transfer of the editorial work the work of the library was continued along the lines previously developed. It is primarily a service and only secondarily a collection of books. There is a two-fold reason for this. First, the literature of marketing and distribution has been, until recently, so scant, and is still so scattered, that it has been necessary to review a large and varied field in order to glean the material pertinent to the subject, and second, the accessibility of the department library, which is in the same building, makes it necessary to have filed in the

bureau library only the books and pamphlets and periodicals which are most frequently needed. One of the important parts of the work of the library has to do with the circulation of the 695 periodicals which it receives. These vary from the highest grade economic and financial journals to the daily price sheet. With the exception of the dailies, they are circulated to 79 divisions, sections, and offices of the bureau, where responsible persons see to the circulation within the unit and the prompt return of the numbers to the bureau library.

In the library of the Bureau of Public Roads, the outstanding event was the decision of the bureau to reorganize the library with a view to making it function as an active force in keeping the staff in touch with the latest information along the lines in which they are working. Miss Orrena Louise Evans was appointed librarian in April in place of Mr. M. A. Hays who, as an editorial assistant, had been connected with the Editorial Division of the bureau since 1918 and had in addition to his editorial duties acted as librarian. Mr. Hays resigned in the spring to accept an editorial position outside of the Government service. With the reorganization of the library work of the bureau, the librarian was relieved of all duties connected with the editing of the bureau's publications, in order that her full time might be devoted to the library work.

The work of the libraries of the Bureau of Chemistry, Bureau of Crop Estimates, Bureau of Entomology, Forest Service, Bureau of Plant Industry, and States Relations Service was continued along the lines reported in previous years. There were no changes in the location or organization of the libraries. In addition to the regular routine work, much time was devoted by the librarian of the Bureau of Entomology to the proof reading and revision of Index II to the literature of American Economic Entomology. In the Bureau of Plant Industry library the revision of all of the mailing lists of the bureau, including both foreign and domestic lists, required several months' work. The library was also called upon for an unusually large amount of translating.

BIBLIOGRAPHY.

No new important piece of bibliographical work was undertaken during the year either by the main library or any of the branch libraries. The work consisted principally of supplying and verifying lists of references in connection with correspondence, in verifying bibliographies contained in Department of Agriculture publications, and in keeping up-to-date indexes and bibliographies previously started which have been mentioned in other reports. A combined list of these bibliographies and indexes was issued in mimeographed form as Library Notes No. 6, in May, 1918. With a few exceptions all of those included are still being maintained.

In addition to the current work on the indexes and bibliographies which are maintained from year to year, a few special lists were prepared last year by the bureau libraries. Among the larger of these were the "Check list of the publications of the Bureau of Plant Industry," compiled in the Bureau of Plant Industry library and issued as Bibliographical Contributions No. 3 of the main library, and a list of references on "Government regulation of prices before 1800 A. D.," prepared by the librarian of the Bureau of Markets.

Mention should also be made of the extensive index of economic literature of American Economic Entomology, 1915 to 1919, inclusive, which was begun by the librarian of the Bureau of Entomology in January, 1919, and completed in April, 1920, but not published by the Association of Economic Entomologists until May 10, 1921. It contained 388 pages and over 40,000 references.

It is the duty of several of the bureau librarians to keep up to date the lists of publications issued by their respective bureaus. In the Bureau of Animal Industry library the mimeographed list of available department publications relating to dairying was twice revised and rewritten. The librarian of the Forest Service prepared and issued in mimeographed form a supplement to the complete list of Forest Service publications, dated November 15, 1915, covering all publications issued between that date and July 1, 1921.

A considerable part of the time of one assistant in the Bureau of Plant Industry library is devoted to the editing of bibliographies accompanying articles published in the Journal of Agricultural Research. As the Journal is four times as large as it was formerly, there are proportionately more bibliographies to be verified and edited. Bibliographies appearing in Bureau of Animal Industry publications are verified in the Bureau of Animal Industry library. In the Bureau of Entomology the librarian assists the editor of the bureau in the verification of all references appearing in the publications of the bureau.

No complete list of the current accessions to the library is now being published, the Monthly Bulletin of the library having been discontinued in June, 1913. The need for information about the resources of the library is, however, partially filled by special subject lists of new accessions to the library which appear in mimeographed publications issued monthly by several of the bureaus. A list of the new accessions of special interest to the Bureau of Chemistry is included each month in the "Monthly Review of the Bureau of Chemistry," under the heading "List of books received in the bureau library"; the accessions of special interest to the Bureau of Entomology are included regularly in the Bureau of Entomology News Letter, and the accessions of interest to the Bureau of Markets are included regularly in its "Bureau News." The monthly list of current forestry literature which was formerly published in "American Forestry," is now issued in mimeographed form by the Forest Service library. The Bureau of Plant Industry library issues semimonthly in mimeographed form a list of references to articles of interest to the Bureau of Plant Industry. In this connection mention should also be made of the Experiment Station Record, which may be considered to a certain extent as an index to the library's resources, as the bulk of the publications abstracted are contained in this library.

DAILY DIGEST.

In March, 1921, the library began to issue in mimeographed form a daily publication entitled "Daily Digest, a summary of news, particularly of an economic character, as contained in the accessions to the library." It is prepared by Mrs. Susan Hunter Walker,¹ under the

¹ Mrs. Walker prepared the Daily Information Digest formerly issued by the Council of National Defense.

general direction of the librarian of the department, with the cooperation of the Director of Information (Office of the Secretary) and of the bureaus of the department. The need for a publication of this kind grew out of the increased attention which has been given to agriculture during the past few months by Congress and by the whole country. The discussion of agriculture is no longer confined largely to farm journals and scientific journals. The general newspapers, literary periodicals, and financial and commercial papers are devoting much space to its problems. The Digest follows from day to day references to agricultural legislation, market conditions, and the opinions and discussions of farm leaders, editors, public men, bankers, and business men in general on the economic problems related to the present crisis in agriculture and on the remedies proposed for its improvement. A summary of this thought seemed to be needed.

CORRESPONDENCE AND MAILING LISTS.

No count of the incoming and outgoing correspondence is kept throughout the year, but a count which was made of outgoing correspondence during one week in April indicated a daily average of 44 domestic letters and 8 foreign letters.

During the year 1,624 orders were issued on the Division of Publications for the mailing of department publications which were requested by foreign institutions and officials and by societies and private individuals from whom publications are received in exchange. The appointment of an assistant to attend to the mailing lists and files made it possible to begin during the year a thorough revision of all foreign mailing lists maintained by the library.

FINANCES.

During the past year 1,569 orders for periodicals and books, 67 for supplies, 132 shop requests, and 41 orders for printing were issued, and 956 vouchers were audited for payment. A comparison of the receipts and expenditures of the library for the past 10 years is given in the following table.

Financial statement, fiscal years 1912 to 1921.

RECEIPTS.

Fiscal year.

	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921
Source:										
Library appropriation.....	\$40,500.00	\$11,280.00	\$43,520.00	\$45,360.00	\$46,020.00	\$49,520.00	\$50,160.00	\$50,160.00	\$50,160.00	\$54,880.00
From department printing and binding fund.....	12,813.95	13,843.31	11,315.84	10,190.62	9,062.12	8,707.32	12,658.38	5,358.21	9,210.70	7,031.20
Total.....	53,313.95	55,129.31	54,865.84	56,550.62	55,082.12	58,227.32	62,228.38	55,518.21	50,370.70	61,911.20

EXPENDITURES.

Books and serials.....	\$6,914.48	\$6,791.73	\$8,083.69	\$8,370.90	\$8,840.39	\$8,898.68	\$7,199.74	\$7,035.57	\$9,423.98	\$9,289.26
Magazines.....	3,706.67	3,625.42	4,283.41	3,586.17	3,978.46	4,093.62	4,252.74	6,104.70	5,193.79	5,840.71
Maps.....			47.50	40		215.00	40.88		70	62.04
Photographs.....	175.00									
Index cards.....	145.89	215.86	171.03	191.88	169.59	129.07	78.86	85.25	112.23	178.51
Furniture, shelving, and miscellaneous equipment.....	965.12	2,635.99	769.37	3,148.23	866.85	552.26	765.58	604.04	293.16	2,525.94
Traveling expenses.....	97.98	38.45			31.20				179.44	219.72
Freight, express, and drayage.....						10.62	16.54	37.75	93.07	56.67
Supplies and repairs.....	164.02	313.27	323.42	350.00	429.16	469.24	981.33	609.01	539.38	518.50
Salaries (main library).....	27,818.17	27,100.27	28,377.29	29,585.50	31,278.06	33,025.33	33,272.25	31,440.95	31,461.85	29,034.60
40,019.33	40,723.99	43,008.71	45,189.68	47,237.04	47,458.73	48,356.24	48,136.50	47,239.22	48,563.91	
3,307.54	4,084.21	1,892.25	1,895.47	1,806.79	1,727.17	1,727.78	652.75	348.56	342.34	
9,566.41	9,759.10	9,153.59	8,295.15	7,855.33	6,980.35	10,491.60	4,705.46	8,862.14	6,888.86	
12,813.95	13,843.31	11,315.84	10,190.62	9,062.12	8,707.32	12,068.38	5,358.21	9,210.70	7,031.20	
52,333.28	54,567.30	54,254.55	55,380.20	56,893.16	58,166.25	60,424.63	53,494.71	56,449.92	55,595.11	

Expenditures for library printing and binding for the fiscal years 1919, 1920, and 1921.

Item.	1919	1920	1921	Item.	1919	1920	1921
Regular binding.....	\$2,734.23	\$8,255.30	\$5,537.74	Publications.....			
Binders.....	1,641.23	665.84	1,151.12	Miscellaneous.....			
Pamphlet boxes.....	330.00	239.38	241.64	Total.....	\$400.36	\$84.30	\$94.61
Forms.....	247.82				4.57	4.88	6.09
					5,358.21	9,210.70	7,031.20

LIBRARY STAFF.

The number of employees carried on the main library staff at the close of the fiscal year was 36. Of this number 7 were temporary assistants, it not having been possible to fill permanently the clerical positions with salaries under \$1,000. The number employed by the bureau, division and office libraries was 43. Of the total number employed in the main library and the bureau and office libraries, 63 were women and 16 were men, divided as follows: Seventeen in administrative work, including the librarian of the department, the heads of divisions in the main library, and the librarians of the bureaus and offices: 28 were library assistants; 19 clerical assistants, 11 messengers, and 4 charwomen.

In the main library there were 11 resignations during the year from the permanent employees. Of this number 5 were library assistants, 3 were clerical, 2 were messenger boys, and 1 was a charwoman. Of the 5 library assistants who left the main library, 2 resigned to accept more remunerative positions in bureau libraries and were not, therefore, lost to the library work of the department as a whole. Out of the staff of 27 in the main library, exclusive of messengers and charwomen, on June 30, 1921, there were only 16 who had been on the library rolls throughout the fiscal year. Of these 15 had been in the library two years and only 12 had been in the library three or more years. Such is the havoc that the low salaries of the library has worked on the trained personnel. This has had a serious effect on the work of the library staff, the efficiency of which depends in a large degree upon the length of service, familiarity with the resources of the library, and the work of the department.

Mention was made in the report last year of the library's policy of offering temporary appointments whenever possible to librarians or assistants connected with the State agricultural college and experiment station libraries who wish to have experience in this library. The assistant librarian of the Virginia Polytechnic Institute and the librarian of the South Carolina Agricultural Experiment Station, worked in the library at the beginning of the past fiscal year, and the librarian of the agricultural library of the Iowa State College began a two months' appointment with us at the close of the fiscal year. It is the aim of this library to bring about close relations in every way possible with the libraries of the State agricultural colleges and experiment stations, as it is believed that this will be to the mutual advantage of both the colleges and the department.

Library staff meetings were held each month throughout the year with the exception of the months of August and September, 1920. The subjects of the various meetings were as follows: Talks by Miss Lillian M. George, of the Oregon Agricultural College Library, and Mrs. Helen S. Torrence, librarian of the South Carolina Agricultural Experiment Station, on the work of their libraries; "Some college and reference libraries of Wisconsin, Illinois, and Indiana," by the librarian of the department; A talk by Miss Adelaide R. Hasse, on her work at the Council of National Defense; A talk by Mr. Dorsy W. Hyde, president of the Special Libraries Association; "A year in Africa," by Dr. H. L. Shantz, of the Bureau of Plant Industry; "Prices," by Mr. Herbert C. Marshall, of the Bureau of Markets; "Some of our old reference books," by Miss M. F. Warner, of the

Bureau of Plant Industry; "Policies and procedure of the library," being a collection of "Do" and "Don't," maxims contributed by members of the library staff.

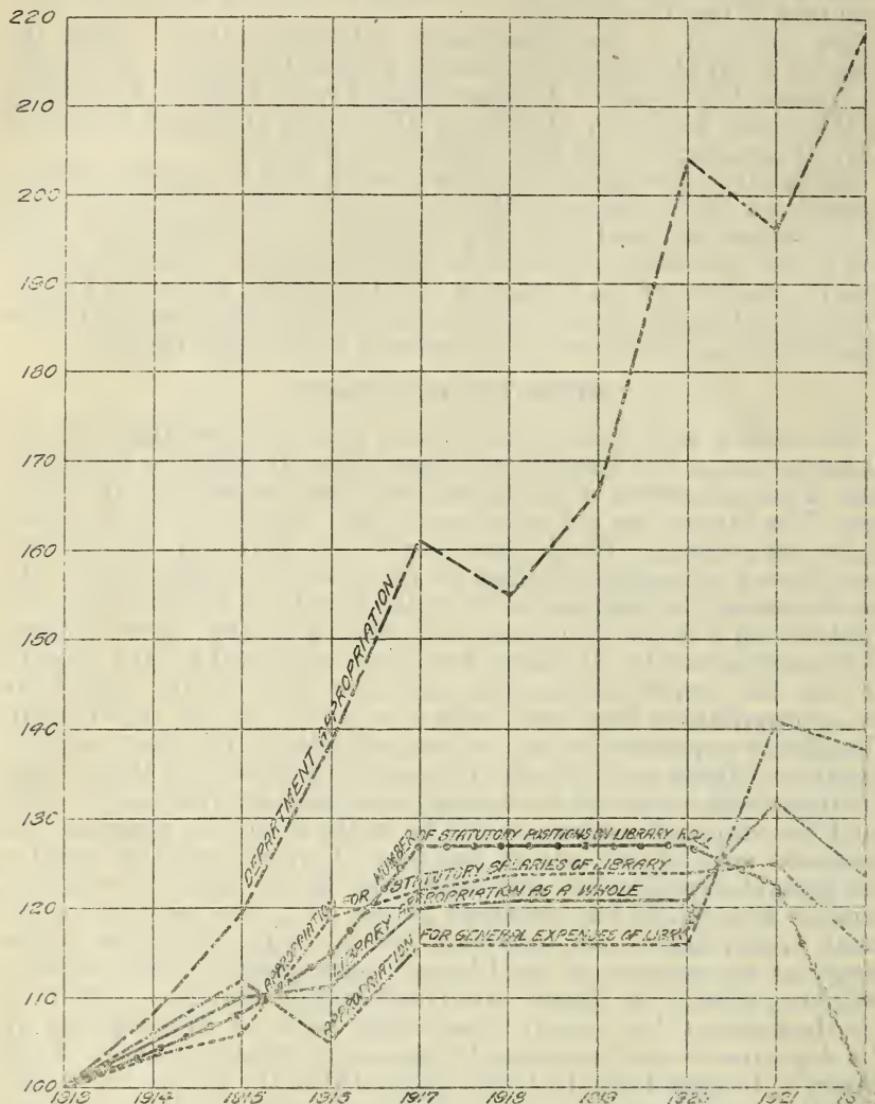
The librarian of the department in October, 1920, visited the libraries of the Ohio State University, Purdue University, University of Illinois, University of Chicago, John Crerar Library, University of Wisconsin, Legislative Bureau of Wisconsin, Wisconsin College of Agriculture Library, and other libraries in Madison.

The library was represented at the meeting of the American Library Association at Swampscott, Mass., in June, 1921, by the librarian of the department and four other members of the main library staff and by six representatives from the bureau libraries. Miss Eunice B. Oberly, librarian of the Bureau of Plant Industry, presented a paper at the meeting of the Agricultural Libraries Section entitled "The contribution of librarians to agricultural history and research."

NEEDS OF THE LIBRARY.

The facility with which scientific and economic investigations can be carried on in the department depends largely upon the completeness of the collections of the library and their accessibility for ready use. The library has not infrequently been referred to as the heart of the department. What affects the library adversely must, therefore, have a corresponding effect on the work of the department. In the accompanying diagram is shown the growth of the library appropriations for the past 20 years compared with the appropriations of the department. It shows the losses sustained by the library in the last appropriation bill and also that in no year have its appropriations kept pace with the growth of the department. The library appropriation as a whole is divided in two parts, one for statutory salaries and the other for general expenses, the latter being the fund from which the books and periodicals are purchased. The fund for statutory salaries, it will be noted from the diagram, has increased only 16 per cent in the past 10 years, and the fund for the general expenses has increased only 38 per cent. The appropriation as a whole has increased 24 per cent, whereas the department appropriation has increased 119 per cent. No other argument for an increase in the library's appropriation need scarcely be given, when it is taken into consideration that this growth of the department has meant broadening fields of investigation by the department and a constantly increasing number of users of the library. It should also be borne in mind that the library serves not only the department but also the State agricultural colleges and experiment stations, which institutions are looking more and more to the library to supplement their resources and for bibliographical assistance. If, therefore, the library is to be able to meet adequately the demands upon it and perform the service which should rightly be expected of the national agricultural library, it must have more adequate support. The present staff is less than 75 per cent of what it should be and the book fund should be doubled. In addition, there is great need of additional space for the library. The stacks are overcrowded and the rooms for administrative purposes are insufficient. Each year the need is becoming more urgent for permanent and fireproof quarters for the library well suited to its requirements and adequate for the housing and convenient use of its invaluable collections.

COMPARISON OF THE LIBRARY APPROPRIATION WITH THE DEPARTMENT APPROPRIATION FOR THE FISCAL YEARS 1913 TO 1922.





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REPORT OF THE CHIEF OF THE BUREAU OF PLANT INDUSTRY.

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
Washington, D. C., September 8, 1921.

SIR: I have the honor to submit herewith a report of the work of the Bureau of Plant Industry for the fiscal year ended June 30, 1921.
Respectfully,

Wm. A. TAYLOR,
Chief of Bureau.

Hon. HENRY C. WALLACE,
Secretary of Agriculture.

WORK AND ORGANIZATION OF THE BUREAU.

The Bureau of Plant Industry deals with the various plant problems of economic importance, especially those relating to crop production and utilization. These activities include the improvement of useful plants by selection and breeding, the investigation of destructive plant diseases and development of methods for their control, the introduction of new plants from foreign countries, the improvement in cultural methods for producing crops, and the development of improved methods of crop handling and utilization.

The bureau maintains field stations and conducts experimental work in all sections of the United States, including experimental work on irrigated lands on Government reclamation projects.

A seed and plant exchange service is conducted between experts of foreign countries and American experts. The bureau supervises the purchase and distribution of vegetable, flower, cotton, tobacco, lawn-grass, and drought-resistant seeds, and of bulbs.

The work of the bureau during the year has been carried on with the following organization:

Laboratory of Plant Pathology	Erwin F. Smith, Pathologist in Charge.
Pathological Collections	Flora W. Patterson, Mycologist in Charge.
Fruit-Disease Investigations	M. B. Waite, Pathologist in Charge.
Citrus-Canker Eradication	Directed by K. F. Kellerman, Associate Chief of Bureau.
Blister-Rust Control	S. B. Detwiler, Forest Pathologist in Charge.
Cotton, Truck, and Forage Crop Disease Investigations	W. A. Orton, Pathologist in Charge.
Crop Physiology and Breeding Investigations	W. T. Swingle, Physiologist in Charge.
Soil-Bacteriology and Plant-Nutrition Investigations	Directed by K. F. Kellerman, Associate Chief of Bureau.

Soil-Fertility Investigations-----	Oswald Schreiner, Biochemist in Charge.
Crop Acclimatization and Adaptation Investigations-----	O. F. Cook, Bionomist in Charge.
Fiber-Plant Investigations-----	L. H. Dewey, Botanist in Charge.
Drug, Poisonous, and Oil Plant Investigations-----	W. W. Stockberger, Physiologist in Charge.
Physiological and Fermentation Investigations-----	H. L. Shantz, Physiologist in Charge.
Agricultural Technology-----	N. A. Cobb, Technologist in Charge.
Seed-Testing Laboratories; Enforcement of Seed-Importation Act-----	E. Brown, Botanist in Charge.
Cereal Investigations-----	C. R. Ball, Cerealist in Charge.
Tobacco Investigations-----	W. W. Garner, Physiologist in Charge.
Alkali and Drought Resistant Plant Investigations-----	T. H. Kearney, Physiologist in Charge.
Sugar-Plant Investigations-----	C. O. Townsend, Pathologist in Charge.
Dry-Land Agriculture-----	E. C. Chilcott, Agriculturist in Charge.
Economic and Systematic Botany-----	Frederick V. Coville, Botanist in Charge.
Western Irrigation Agriculture-----	C. S. Scofield, Agriculturist in Charge.
Horticultural and Pomological Investigations-----	L. C. Corbett, Horticulturist and Pomologist in Charge.
Arlington Experimental Farm-----	E. C. Butterfield, Assistant Horticulturist in Charge.
Gardens and Grounds-----	E. M. Byrnes, Assistant in Charge.
Foreign Seed and Plant Introduction-----	David Fairchild, Agricultural Explorer in Charge.
Forage-Crop Investigations-----	C. V. Piper, Agrostologist in Charge.
Congressional Seed Distribution-----	R. A. Oakley, Agronomist in Charge.
Demonstrations on Reclamation Projects-----	A. C. Cooley, Agriculturist in Charge.

From September 1, 1920, to August 31, 1921, the changes in the personnel of the bureau were as follows: Resignations, 480; deaths, 7; transfers from bureau, 37; furloughs, 7; retirements, 3; terminations of appointments, 511; making a total of 1,045 employees dropped from the rolls during that period. In the same period 1,060 appointments were made, leaving a net increase of 15 in the total force of the bureau. On September 1, 1921, the numerical strength of the bureau was as follows: In Washington, 724; outside of Washington, 1,127; total, 1,851. The total number of employees in the bureau on the same date a year ago was 1,836.

The new publications of the bureau (Department Bulletins, Farmers' Bulletins, circulars, and miscellaneous documents, with contributions to the Yearbook and to the Journal of Agricultural Research) number 139, of which 13 were joint contributions with educational institutions or with other bureaus or offices of the department. These 139 publications contain 3,223 pages, 238 full-page plates, and 793 text figures, and were issued in first editions aggregating 1,738,100 copies. The number of publications issued during the preceding fiscal year was 74, containing 2,144 pages, 155 full-page plates, and 774 text figures, the first editions aggregating 1,258,760 copies. The contributions of this bureau to the series of Farmers' Bulletins numbered 37 in 1918, 29 in 1919, 14 in 1920, and 37 in the fiscal year covered by this report. Of the Farmers' Bulletins issued in previous years, 15 were extensively revised. One paper emanating from this bureau was printed in the Yearbook of the Department for 1920. The number of contributions from this bureau to the Journal of Agricultural Research was 40.

AGRONOMY, CROP BREEDING, AND HORTICULTURE.

WHEAT.

Extension of wheat varieties.—Progress is being made in the development of improved varieties of wheat at several stations. At Arlington Farm a high-yielding selection from a cross of Currell and Fultz is being increased for distribution. In the cooperative experiments at Cornell University a selection from Dawson, which has been named Honor, has been developed. This is now being grown by farmers and promises to increase rapidly in popularity. Three varieties with red kernels also have been distributed in a limited way from Cornell University. One of these has been named Forward.

In the hard spring-wheat district the acreage sown to Marquis is decreasing, because that variety is not resistant to rust. In some sections Marquis is being replaced by durum wheat, particularly Kubanka, and three durum pure lines which are more resistant to rust than Kubanka are also coming into popularity. These are the Acme in South Dakota, the Monad in North Dakota, and the Mindum in Minnesota. The fact that durum wheats yield better than Marquis and other hard red spring wheat where the moisture is insufficient is also increasing the popularity of the durum varieties in North Dakota and Montana. The Kota, a bearded hard red spring wheat, appears to be decidedly rust-resistant, and experiments so far indicate that its grain is of good milling quality. It is being increased as rapidly as possible for distribution.

In the hard red winter-wheat district, particularly in Kansas and Nebraska, the Kanred, a high-yielding, rust-resistant strain developed at the Kansas station, continues to increase in popularity. It is estimated that between 3,000,000 and 4,000,000 acres of Kanred wheat were grown in 1921.

In the Pacific coast district the Early Baart wheat, introduced by the department about 20 years ago, is becoming increasingly popular and is replacing other varieties to a considerable extent. Three more recently introduced Australian wheats, Federation, Hard Federation, and White Federation, appear to yield better and to produce grain of better quality than Early Baart under certain conditions. Of these, Hard Federation seems to be best for the dry lands of Oregon, White Federation for the central valleys of California, and Federation for the irrigated farms of the Great Basin. In southern Idaho the Dicklow, improved and distributed from the Aberdeen Substation, is now the most widely grown wheat on irrigated lands.

Wheat classification.—The classification of American wheat varieties has been completed, together with a key for the identification of about 230 commercial varieties. These varieties are minutely described, their histories recorded, and their distribution shown. A list of synonyms brings the total number of names up to about 850. The distribution was determined by a varietal survey from which 40,000 returns were received. The proportion of the total acreage in each county which was sown to a given variety was determined from these reports, and the acreage of the variety by counties and States was then calculated from the census figures of total wheat acreage. The wheat classification studies have been con-

ducted for six years, and during their progress more than 25,000 separate sowings were made.

CORN.

Corn breeding.—In genetic studies about 10,000 corn plants were self-pollinated for the purpose of isolating certain combinations of characters that appeared to affect directly the yield and quality of the grain. This work is now in progress for the fifth season. Some of the desired segregations have been obtained and others are gradually being made.

Experiments are being conducted in Arkansas in mass selection and pure-line selection from the hybrid between Whatley, a prolific variety from Georgia, and St. Charles White, a Missouri variety. Selections have been made each year during the past six years, and remnant seed of each generation has been retained. These remnants are grown from time to time alongside the latest selections, so that any improvement which has been made can be measured. Pure-line selection has been in progress since 1917. In 1921, 250 selfed ears were planted, these being from strains continuously selfed for five generations. Crosses were made between a number of the best selfed strains in 1920, and these are being grown in 1921. In a number of cases the crossed seed was grown in the greenhouse during the winter of 1920-21, and selfed seed matured in time for planting in the field in the spring of 1921, thus enabling selection from two generations in a single year.

Utilization of corn.—Studies have been made of the relation of kernel characters to quality in pop corn. It has been shown that increase in volume and popping is closely correlated with freedom from soft starch in the endosperm. In general, varieties of pop corn with small kernels give greater relative increase in volume when popped than those with large kernels.

Preliminary experiments with varieties of corn, suitable for hogging down are being conducted in Arkansas and Illinois. These include the growing of early northern varieties so as to provide a succession. These varieties appear to yield well enough to make their planting on small acreages advisable.

Acclimatization of Indian corn and teosinte.—Native corn varieties in Central and South America thrive and produce satisfactory yields under a much wider range of climatic and soil conditions than our North American varieties, and are suited to different uses as food. Studies of foreign varieties have shown that they possess special characters or adaptations that fit them especially for the local conditions where the varieties are grown, and probably were developed. Through the introduction and hybridization of many imported varieties it has been possible to develop strains that have special resistance to low temperatures, drought, high winds, and attack of insects. In studying the range of adaptation of varieties in the United States it has been demonstrated that with the effects of selection eliminated transfers of seed from one locality to another is beneficial rather than otherwise. Through hybridization with southern varieties of field corn, a strain of sweet corn has been developed that is partially immune to the attacks of the corn worm. Seed is now being grown for commercial distribution, and other new types of corn that may be eaten like sweet corn or in other ways

are being selected. By hybridizing corn with related grasses, Euchlaena and Tripsacum, plants of many intermediate forms have been produced, some of which give promise of value as forage crops, if sufficiently uniform stocks can be developed by selection, which is still in progress.

OATS.

The breeding of spring oats has been continued in cooperation with the New York, Iowa, and Idaho Agricultural Experiment Stations and of winter oats at Arlington Farm, Va. The principal problem is the production of high-yielding varieties for various conditions. Practically all of those so far produced have been pure lines selected from commercial varieties, but efforts are also being made to combine the different qualities of good strains by hybridization.

Studies are also being made in cooperation with cereal-disease workers on the resistance of oat varieties to stem rust, crown rust, and smut. The few varieties which appear to be resistant to these diseases are, for the most part, not commercially important, and they are being combined with the better commercial varieties in the hope of producing resistant strains which will produce high yields of good quality.

The best crop of winter oats ever grown at Arlington Farm was produced in 1921, the highest yield being slightly over 100 bushels per acre. As in previous years, the Winter Turf has proved to be best adapted to conditions at Arlington Farm; but farther south, in the winter-oat belt, the Fulghum and Red Rustproof are better, because of their earlier maturity. The Fulghum is also becoming popular for spring sowing in Kansas, Missouri, and other States with similar conditions where spring oats are generally unprofitable.

In New York four pure lines have been named and distributed to farmers. These are the Cornelian, Comewell, Standwell, and Empire. The Cornelian is a comparatively early variety, which has yielded well generally in the State of New York. The principal objection to it is that the kernels are small and grayish in color, so that it would not sell well on the market. Hybrids between this and several of the better varieties of white oats have been made in the hope of producing a white oat larger than the Cornelian but with its other good characters. Comewell, Standwell, and Empire are selections from mid-season white oats which are giving favorable results in different sections of New York. All these varieties are in demand where they are known, and practically all that have been produced so far have sold readily for seed.

Albion and Richland, developed several years ago in the cooperative experiments with the Iowa station, continue to be popular. The Iowar, a white selection from Kherson which appears to yield slightly better than Albion, seems likely to replace that variety to a considerable extent. The Iogren, a high-yielding selection from Green Russian, one of the most popular varieties in northern Iowa, was first distributed in 1921. This variety should be valuable in northern Iowa, southern Minnesota, and in other States with similar climatic conditions. The Albion is grown on very large acreages in Iowa and Illinois, and to a considerable extent in other Corn Belt States.

The Idamine, a high-yielding, pure-line selection from Silvermine, developed at the Aberdeen (Idaho) substation, was first distributed in 1921, when several hundred bushels were available. This oat should prove popular generally for growing on irrigated lands in Idaho and adjoining States.

BARLEY.

Considerable progress has been made in producing varieties of barley adapted to various conditions. Among the varieties which are becoming commercially important are Trebi, a pure-line selection particularly well adapted to growing under irrigation in the Great Basin, which is now so widely distributed that most of the barley acreage in southern Idaho will soon be of this variety; Mariout, distributed from the Moro (Oreg.) substation, now commercially grown in California on the dry lands; and Flynn, a smooth-awned segregate from the cross Mariout \times Lion. Flynn has proved to be the best yielder among the number of smooth-awned strains grown in cooperative experiments at the Moro substation, and it is being increased for distribution.

Two varieties originated and developed in cooperative experiments with the Minnesota Agricultural Experiment Station have been widely tested on farms in New York, where they have proved so valuable that they are in demand among farmers and are being offered by dealers. These are Featherston, a six-rowed, awned selection, and an unnamed two-rowed, awned hybrid derived from Manchuria \times Champion of Vermont.

RICE.

Further distribution has been made of the most promising of the new varieties of rice developed at the Crowley, La., and Biggs, Calif., stations. In Louisiana about 10,000 acres were sown this year of the two new varieties, Acadia and Fortuna. Another new variety which is likely to prove popular is the Vintula, a long-grained rice, which is being grown on the prairies of western Louisiana. In California a selection of Early Wataribune, which has been named Calora, was distributed for the first time in 1921. This is a high-yielding selection, which matures 10 days to 2 weeks earlier than Wataribune, and which is likely to prove very popular.

TRUCK-CROP PRODUCTION INVESTIGATIONS.

Sweet potato.—The past year has seen the completion of certain phases of the sweet-potato work which have been in progress for a number of years. Perhaps the outstanding feature is the bringing to a close, tentatively at least, the classification of sweet-potato varieties and the preparation of a varietal key.

Great confusion has existed for a long time in sweet-potato variety nomenclature. The same variety has been known under different names in different localities without the fact being realized that the same variety was thus involved. As a result of the systematic work some 40 well-defined varieties are now recognized as being used for stock seed purposes and are being disseminated to the various State experiment stations and other institutions which are in a

position to increase these stocks and supply them to growers. Only a few of the varieties, however, are of recognized commercial importance from the standpoint of production for food purposes. In the preparation of the varietal key above referred to, several hundred so-called varieties have been studied, but this number has been reduced by comparison and otherwise until, as above indicated, only about 40 varieties out of the total of several hundred names are now recognized as distinct. The key is based on the character of the foliage, length and color of the stem and petioles, the color of the roots, and other characteristics.

A continuation of the sweet-potato curing and storage investigations has again demonstrated not only the possibility but the practicability of holding some of the more important varieties, such as Nancy Hall, Porto Rico, and Southern Queen, throughout the entire winter and spring months with a decay loss of less than 1 per cent and a shrinkage loss of only 12 to 15 per cent. The curing and storage work has now been in progress a sufficient length of time, not only as a definitely experimental project but also as a practical commercial feature, to justify the compilation of the data that have been accumulated and the preparation of a manuscript for publication as a Department Bulletin under the title "The Storage of Sweet Potatoes in the Government Type of Storage House." Another aspect of the sweet-potato storage investigations closely allied to the foregoing, particularly in the tobacco-growing regions of the South, where sweet potatoes are also extensively grown, is the adaptation of the flue-heated tobacco barns to sweet-potato curing and storage. As there would be no conflict of time in the use of the tobacco barns for tobacco-curing purposes and sweet-potato curing and storing, the advantage of using these barns also for sweet potatoes became evident in the progress of the sweet-potato work. Some experimental tests were therefore arranged, and these have been continued to the point where it has been demonstrated that, with comparatively slight changes which can be easily provided for, the tobacco barns can be converted into very efficient sweet-potato storage houses. The only changes that are necessary in converting a tobacco barn into a sweet-potato storage house is the installation of a false floor and when bins are to be used the making of the necessary partitions. Where crates are used the building of the false floor is the only requirement. In either case it is entirely practicable to construct both the floor and the bins in such a way that they can be readily put in place when needed and removed when that becomes desirable, all of the parts being so constructed as to be removable without any breakage.

Canning crops.—While crops used extensively for canning have long been studied in connection with the vegetable-production investigations, there have arisen a number of very important and practical problems during the past year or two; and hence, because of the demands which were coming for information, additional attention, especially from the canning standpoint, has been given to certain of these crops, particularly to tomatoes and peas, with limited attention to some of the other crops, such as sweet corn, beets, and beans. Because of the great importance from the food standpoint, as well as from the standpoint of the canning industry,

of tomatoes and peas, attention during the past growing season was directed largely to these two crops, the object being to study cultural methods and requirements best adapted to some of the important production regions and to the varietal purity of the seed stocks used. Very great losses in recent years have been suffered, not only by the grower's but by the canners, through the use of seed stocks not true to name. This applies particularly to peas. During the pea-picking season of 1920 it was found that spurious seed of the Alaska variety extensively used for canning had been sold in Maryland and Delaware and that some 1,700 acres had been planted with the spurious seed for canning. From an examination of the fields it became evident that there were two varieties involved. One of them produced long, late plants, usually with a poor crop but containing only a few plants with purple flowers. The product of this variety which was canned was salable. The other variety also produced long, late plants, many of which bore purple flowers. The peas from these plants turned dark on being processed and were therefore of no value for canning.

The loss as compared with the product from the true Alaska was not only in the crop itself, which was of concern both to the grower and to the canner, but in some instances it matured so late as to prevent any succession crop being grown on the same land. It seems certain that the peas, which were long vined, but which produced no colored flowers, came largely from the region about Moscow, Idaho, while the other type probably came from the Puget Sound region. The colored-flower plants are of the Bangalia variety, which is grown most largely about Puget Sound. The other long-growing, white-flowered variety that was in the mixture does not represent any well-recognized variety of field peas. It is considered probable that they may be Alaskas that have broken from the type, constant roguing of Alaska seed stocks being recognized as necessary in order to eliminate such spurious off-types.

Peanut investigations.—Because of the potential possibilities of the peanut for forage-crop purposes, as a source of a valuable vegetable oil, as a crop to grow in some of the regions formerly devoted largely to garden, as well as for other purposes, the peanut investigations continue to be one of the most important lines of study grouped under the general truck-crop production project. The investigational work is located for the most part at Florence, S. C., at the Pee Dee field station of the South Carolina Experiment Station. The investigations in progress involve spacing tests in planting, tests of shelled versus unshelled seed, the effect of the time of shelling on the germination of the peanuts, rotation tests, breeding work, and fertilizer experiments. Peanuts planted after being shelled for different lengths of time showed great differences in germination. For instance, peanuts that were shelled 68 days before planting gave only 3.7 per cent germination and a yield of $3\frac{1}{3}$ bushels per acre; planted 19 days after shelling the germination was 78 per cent and the yield $41\frac{1}{3}$ bushels per acre; planted 1 day after shelling the germination was 94 per cent and the yield $64\frac{2}{3}$ bushels per acre. A delay of even 9 days after shelling gave appreciably lower results than did immediate planting. A 9-day delay resulted in a germination of only 85 per cent, as compared with 94 per cent when there was a delay

of but 1 day after shelling, as stated above, and the yield in the 9-day delay lot was but $55\frac{1}{2}$ bushels per acre.

VEGETABLE UTILIZATION INVESTIGATIONS.

Drying sweet corn.—Here as elsewhere the work has had a two-fold objective; it has aimed at development of practical methods for making the best possible product, and also to ascertain the comparative values for drying purposes of the numerous varieties generally grown.

In the matter of drying methods, it is felt that satisfactory results have been secured and that no very material improvement in methods of preparatory treatment and handling in the drier can be made. Samples of the product made during the past two seasons have been subjected to comparison with similar productions from various sources with results very favorable to our methods.

Some quite definite differences in the merits of different varieties for drying have become evident. Twenty-two different varieties were employed. Fifteen of these have been under test for three seasons, the others only for two. Of the 22 varieties 17, for various reasons, could not be recommended to persons interested in growing corn for drying.

Drying sweet potatoes.—In an earlier report it was stated that a method for drying sweet potatoes, which we regarded as practical, had been worked out. It was recognized that in order to have any possibilities commercially the cost of preparation and drying must be kept down by the use of simple drying equipment and the employment of machine preparation and that the product must have attractive appearance in the dry condition, must be capable of quick preparation for the table and of use for a wide range of purposes in cookery, and must retain the characteristic appearance and flavor of the fresh potato when prepared for the table. It was believed that these conditions had been met, but it remained to be determined this year whether the dry material was sufficiently nonperishable to enable it to be handled commercially, a difficulty upon which many attempts to make dried sweet potato or sweet-potato flour have come to grief.

Samples of dry sweet-potato material made by our method have now been kept in ordinary storage in insect-excluding but not airtight or moisture-proof containers in office rooms and in the laboratory building at Arlington Farm for more than two years without discoverable deterioration. Samples of potatoes made from the crops of 1918, 1919, and 1920 have been shown to many people, most recently to the conference of extension directors of the various States, without anyone being able to distinguish material 2 months old from that 27 months old. Cooking tests upon lots of material from the crops of the three years show that no change in flavor or table quality has occurred in the older material.

Freezing points of potatoes and other vegetables.—Determinations of the freezing points of a large variety of vegetables have been made and the work is still in progress. Freezing points of some 18 varieties of sweet potatoes before and after curing have been made. The freezing points of cauliflower, celery, peas, string beans, lettuce, cucumbers, egg plants, and other types of vegetables which may be

subjected to the freezing conditions during harvesting, handling, or marketing have been determined. The freezing points of Irish potatoes, some 18 different standard varieties grown under the same cultural conditions, harvested at the same time and stored at the same temperatures, were determined. The freezing point apparently varies with the variety and shows a tendency to vary with the family group. It is shown that potatoes can frequently be exposed to temperatures much below their freezing points if they are not disturbed until the temperature is again above the freezing point. As an example of this, potatoes were exposed to temperatures as low as 25° F. for 72 hours without injury. The temperatures to which the potatoes may be undercooled before freezing, if allowed to remain absolutely quiet, are being determined. This point is apparently one of the most important considerations in the freezing of potatoes and a careful determination of this temperature under different exposures will be of considerable value to the potato grower and handler.

VITICULTURAL INVESTIGATIONS.

Vinifera grape investigations.—As in previous years, the work with Vinifera grapes has been confined practically to California, although limited attention has been given to the possibilities of growing this type of grape in other parts of the country as a result of an apparently increasing interest in such development in certain sections. Perhaps the most outstanding interest centers upon some of the newer varieties. The investigations with Panariti, Monukka, Chanez, and other shipping grapes were continued and it can now be said that the Monukka not only gives the raisin industry a variety of intrinsic merit, destined to become one of the most important raisin grapes, but the Monukka is also a very superior early shipping grape. The viticultural investigations have furthermore started two important new grape industries, namely, the growing and curing of the currant grapes and the growing and shipping of the Ohanez and other Almerian varieties. Both Panariti and Ohanez are now profitably grown in California in sufficient quantity to insure their future importance.

For several years past it has been with considerable difficulty that the owners of the land on which the Fresno and Oakville vineyards are located have been induced to renew the contracts under which those vineyards have been operated since they were started. Because of this difficulty and the probable coming of the time, not far distant, when it would be impossible to continue these vineyards under the arrangement that has been in effect, an effort has been made to secure an adequate appropriation from Congress to enable the department to purchase the land and equip the vineyards with the necessary buildings, wells, tools, and other things. Near the close of the last session of Congress authority was given to the Secretary of Agriculture to purchase the two tracts occupied by the Fresno and Oakville vineyards, although the act conveying this authority carried no appropriation. It is to be noted further that one of the deficiency bills recently passed by the present session of Congress contained an item appropriating \$12,000 for the purchase of the Fresno vineyard and \$15,000 for the securing of the Oakville vineyard.

Muscadine grape investigations.—During the year closer cooperation has been established between the Bureau of Plant Industry and

the North Carolina State Department of Agriculture and Experiment Station. This is perhaps the most outstanding development during the past year. The closer relationship consists of the appointment by the North Carolina Experiment Station of the leader of the Muscadine grape project as assistant director of that station, with assignment as superintendent of the trucking branch station at Willard, N. C. He also continues to direct the Muscadine grape work, not only of the Bureau of Plant Industry but of the North Carolina Experiment Station.

There has developed during the year a demand by individuals not only for information but plants with which to start the business of grape production. The nurserymen alive to the situation are co-operating to the extent of trying to meet the demand for plants and have purchased large quantities of cuttings from the cooperative vineyard for use in their work. The agricultural press is taking note of the department's work and for the first time is featuring by special articles the advantages of Muscadine grape growing. The railroads have carried Muscadine grape products on their diners for over one year, and are continuing to feature them. The home demonstration organization is proceeding with its side of the work, and in Alabama the canning club girls have reached the point of filling commercial orders, while in all the Southeastern States the planting of Muscadine grapes by the club girls goes onward. The companies using Muscadine grapes for the purpose of preparing fruit flavoring sirup and dealcoholized beverages continue to increase their plantings and output, and during the year have increased their capitalization materially.

The foregoing comments with regard to crop and product conditions apply to the season of 1920. The outstanding features of the season 1921 thus far are closely connected with the unusual climatic conditions that have prevailed. These, briefly stated, were exceptionally warm weather during February and March, during which the vines made an unusual growth and were much advanced beyond normal for the date when some freezing temperatures were experienced. Following unprecedented warm weather, continuing without interruption throughout February and March, an extremely heavy late freeze was experienced on April 12. The warm weather caused growth to be abnormally far advanced and the freeze killed all the season's growth; but the vines have resprouted from dormancy and adventitious buds, and the new growth carries enough bloom buds to insure an average crop if the weather in June (the blooming time) is normally good. Under the same local conditions peaches and pecans registered a total loss, and the estimated crop reduction for other fruits and truck was as follows: Pears, 50 per cent loss; apples, 70 per cent loss; strawberries, 30 per cent; dewberries, 30 per cent; beans, 90 per cent; tomatoes, 100 per cent; potatoes, 70 per cent; cotton, 40 per cent; sweet corn, 80 per cent.

Fruit improvement through bud selection.—The leading citrus growers in California are keeping individual-tree records of the behavior of their citrus trees, which records are used by the growers for the purpose of locating undesirable trees for top-working and for securing definite information concerning orchard practices. Wherever desired the owners of these orchards have consented to the use of the superior trees, as shown by their performance records,

as sources of bud wood for propagation. Bud wood from these trees is being secured and distributed at cost by the bud department of the California Fruit Growers' Exchange. In this way the results of these investigations are made of commercial value to the industry.

Cooperative work with the California Fruit Growers' Exchange in the selection and distribution of the buds of superior trees from performance-record orchards, which was inaugurated in May, 1917, has as a result of these investigations reached a point where it has become an important branch of the work of the California Fruit Growers' Exchange. Nearly 1,300,000 buds have been cut from superior trees in the performance-record orchards and furnished to nurserymen and orchardists. During three months of the current year more than 275,000 buds were supplied. This work has become so firmly established and the beneficial results of it have been so clearly demonstrated that it has become recognized as an essential part of the work of this cooperative organization of more than 10,000 citrus growers in California. In addition to the selection of superior trees as sources of bud wood for propagation, the cutting of bud wood from these trees and supplying it to nurserymen and orchardists, it has been found possible to establish an experimental nursery at Lamanda Park, near Pasadena, Calif. In this nursery of $7\frac{1}{2}$ acres, located under the most favorable conditions for the growing of citrus nursery stock, extensive experiments have been undertaken during 1920 along the line of methods of propagation, budding, and care of the nursery trees. Furthermore, it has been found possible in connection with this experimental nursery to undertake the study of citrus stocks and the relation of these stocks to tree growth and development. The carefully selected seed from individual trees of the sour orange, *Citrus aurantium*, and seeds secured from carefully selected individual sweet-orange trees, *Citrus sinensis*, have been planted in separate plats in the nursery. A small number of some other citrus stocks will be included with this experiment.

In recent years citrus nurserymen have been growing their nursery stock in such a way that the progenies of the different parent trees are kept separate in the nursery. Wherever possible, arrangements are made to keep these progenies separate in the orchard. In this way the foundation has been laid for a large amount of cooperative commercial progeny-record work, through which it will be possible to trace the behavior of the progenies and compare these records with the performance records of the parent trees from which the progenies were propagated.

The progeny records of carefully selected parent citrus trees are continually revealing new and important information bearing upon the principles underlying the propagation and tree care of citrus and other fruit varieties. For example, the records of the behavior of the progeny of a heavy-bearing Lisbon lemon tree, where the parent tree had one sporting branch and where the buds secured for propagating the trees in this progeny were obtained from other branches than the sporting limb, show very variable and inferior fruiting trees. This and much other similar evidence demonstrates that it is important to secure budwood for commercial propagation

from carefully selected stable parent trees which are known to produce only uniformly good fruits and without marked variations or sports. The trees in the progenies from the superior parent trees have produced uniformly good fruits and are producing upon large commercial orchard areas much larger crops and fruits of better commercial quality and value than those trees where no bud selection had been practiced. The uniformly good type of fruits borne by a citrus tree and the absence of sports or marked variations indicate an inherent stability of type characteristics. This condition has demonstrated that it is practicable to grow uniformly good crops of fruits through the use of trees propagated from superior performance-record parent trees—a matter of fundamental importance from both the production and marketing standpoints. Through bud selection it is possible to propagate and grow uniformly good strains and eliminate the inferior strains which exist in the established varieties. In this way the efficiency of the varieties for the production of fruits can be greatly improved and stabilized, whereby the fruit crops can be most economically grown and marketed.

The trying out of the particular types of trees of the different strains of the important citrus varieties through propagating a small number of nursery trees from the select parent tree is being carried on as opportunity permits. This work is being conducted in cooperation with the Citrus Experiment Station and with the citrus nurserymen and citrus growers.

The observations upon the results of different methods of pruning citrus trees, and the Washington Navel orange in particular, were conducted in 1920 as during the preceding years. The results of these experiments to date have been submitted for publication by the department, and the results of some phases of these studies have been presented as an emergency measure to the citrus growers through meetings and the agricultural papers which circulate amongst the citrus growers. It has become clearly evident that the several radical pruning practices in vogue during recent years in many citrus orchards in California have been detrimental to the development of the trees and have reduced the production of the heavily pruned trees about in proportion to the degree of severeness of pruning which has been practiced.

Observations upon the results of controlling humidity in lemon storage rooms have been continued during 1920. The humidifier developed in the course of these studies for use in fruit storage rooms is now being manufactured commercially at Pasadena, Calif. The leading architect of citrus packing houses and other fruit storage houses in southern California had adopted this humidifier or a modification of it for use in storage rooms in all of the packing houses under construction in his work. The necessity for and desirability of controlling humidity in these storage rooms, which was first developed and demonstrated in the course of these investigations, has become generally practiced. Uniform humidity has been found to reduce the loss in weight of fruits in storage and to promote the development of the fine texture and color of the stored fruits, which is an important factor in marketing these crops. The importance of the conditions of humidity in the storage or curing rooms is now looked upon as equal to that of the temperature conditions. While oranges are not as a

rule held in storage, it has been advantageous to do so. This is frequently done during periods when the atmosphere is so dry that the skin of the fruit quickly becomes somewhat hardened and unattractive in appearance. It has been found that by holding a uniform condition of humidity in the storage rooms of between 80 and 90 per cent of relative humidity it is possible to overcome the difficulties otherwise experienced.

During 1920 an extensive survey of prune orchards was made in northern, central, and southern California. In the course of these studies it was found that the French prune variety is extremely variable. Five distinct strains of this variety have been studied, which have clearly recognizable tree and fruit characteristics. Individual trees were found which were bearing three distinct types of French prune, the trees having been grown from a single bud. Numerous cases of bud variation in trees of the French prune and other prune varieties were observed. Orchards in which the conditions are apparently favorable for securing valuable individual-tree performance-record work have been located, so that when the opportunity permits this work can be intelligently undertaken and carried out.

At the time that the survey of the prune orchards was made in 1920 a similar survey was made of the conditions in apricot and peach orchards—i. e., in northern California. In these orchards a considerable amount of variation was found, and some striking bud mutations were discovered. It is probable that a considerable amount of the diversity in the apricot and peach trees studied is due to bud variation, and that individual-tree performance records will lay the foundation for the isolation and propagation of superior strains of these varieties.

FRUIT-UTILIZATION INVESTIGATIONS.

Three years ago there was begun a study of the comparative value of apple varieties for various by-product purposes. Since that time an effort has been made each season to prepare by uniform routine methods a sample of dried product from each of the varieties fruiting in the variety orchard at Arlington Farm. All the material obtained has been stored under conditions approximating as closely as possible those to which such products are subjected in ordinary practice, so that the data obtained cover, for some 240 varieties, figures for two or three successive seasons on such points as yield of dry product per unit of fresh fruit, market and table quality of the product, behavior in storage, and similar matter of immediate practical interest. On the basis of the information thus secured it is possible to give definite advice as to desirable and undesirable varieties to be employed for evaporating purposes.

A study of the deterioration of evaporated apples after prolonged storage has been begun. In so far as the results thus far obtained indicate, the alteration in color—a progressive darkening or browning of the flesh—which evaporated apples undergo in storage is independent of temperature, moisture content, and, to a very large extent, of access of air. It varies greatly in the rate at which it develops in different varieties, but ultimately appears in all. Fruits low in sugar content and high in acidity and in tannin content very rapidly develop a degree of discoloration, which renders the product

unmarketable, even under the best storage conditions and with low moisture content, after six to nine months. Fruits low in sugar content and low in acidity and tannin content develop discoloration much less rapidly, those high in sugar and low in acidity and tannin still more slowly.

Treatment with sulphur dioxide very greatly retards discoloration in all classes of fruit but does not prevent its ultimate appearance. Treatment with salt solution, moist heat up to 212° F. and partial cooking under steam pressure temporarily inhibit the color change but subsequently allow it to go on more rapidly than in sulphured fruit. The change is independent of enzym action, the presence of organisms and access of oxygen, and is apparently due to spontaneous decomposition of some constituent, either tannin or a pigment, more probably tannin. There is concurrent production of a pronounced bitter flavor due either to the formation of an organic acid or transformation of malic acid. This problem is a phase of the general problem of the pigments and color changes in fruits and vegetables which is being undertaken.

During the year a very considerable part of the time has been devoted to work on clarification of juices or to a study of the physical and chemical effects of various clarifying agents and processes. Of the approximately 300 varieties of apples and 65 varieties of grapes whose juices have been studied, something like 20 varieties of apples and 10 varieties of grapes make juices which in quality equal or exceed the standard commercial product and have continued to do so through three years which have shown wide seasonal variations in the raw material. These juices, when properly clarified and pasteurized, are of quality to compete with any now made and will satisfy the demand for high-quality products. This can be said of only relatively few single variety juices.

The great bulk of the varieties remaining may be grouped into three classes, none of which hold any possibilities as single-variety juices: Those relatively high in sugar but low in acid, which yield insipid juices; those high in acid but low in sugar, which are disagreeably acid juices; and a small number high in tannin or in tannin and acid, which give harsh, astringent juices, as in the case of some grape varieties. These juices can be made of acceptable beverage quality only through blending to obtain a proper acid-tannin sugar ratio; in the case of apple juices a very serious difficulty arises through the fact that practically nine-tenths of the varieties generally grown yield juices of the insipid class, and the high-acid and high-tannin varieties are so little grown that they do not exist in sufficient quantity at present for blending purposes.

NUT INVESTIGATIONS.

Pecans.—Work of the past year has been continued along practically the same lines as have been in progress for several years preceding. Studies have been made of the behavior of varieties in the several localities, with the result that the question of varieties to be recommended to prospective planters has become even more perplexing. Yields are not proving to be what were expected; old varieties, hitherto regarded as being practically immune to certain serious fungous troubles, have in many cases suddenly proved seri-

ously subject to those diseases, and certain new troubles and pests have appeared. Altogether these facts indicate that much greater vigilance upon the part of average orchardists will be necessary than is generally realized, if the industry is to give anything like the returns that have been expected.

In general, the year's results indicate that many of the pecan orchards planted during the past 15 years have been located in soils so ill adapted to their successful culture as to be unlikely ever to become remunerative. Numerous complaints of unsatisfactory returns from such orchards have been received. These have been accompanied by appeals for instruction in the care of pecan orchards in order to overcome the unfavorable conditions.

In an effort to assist growers in meeting this problem, serious study and experimentation in the matter of increasing and maintaining soil fertility has been continued. Fertilizer and cover-crop experiments have been conducted in orchards near Oglethorpe, Putney, and Dewitt, Ga., and Monticello, Fla. These experiments involve the growing and turning under of cover crops, such as cowpeas, velvet beans, soy beans, rye, and oats, both with and without commercial fertilizers of various formulæ. This work has been in progress for three years. The soils selected were of moderate fertility, both extremes in this respect being avoided.

The work thus far accomplished, which is regarded as merely preliminary, strongly indicates that pecan orchards should be planted in good soils only, or in those which may be brought up to high condition of fertility by cultural treatment without prohibitive expense. Also it has been emphasized that in choosing a site for planting a pecan orchard, examination of surface soils is not sufficient, as many times topsoils appear suitable, when, as a matter of fact they are underlain with impervious or other unfavorable subsoils.

The uncertainty of the pecan crop from uncultivated trees was probably never better emphasized than during the past year. The 1919 crop in Texas, alone, variously estimated at from 600 to 1,000 cars and rated as being the largest in the history of the State, was probably not in excess of 10 cars in 1920. The Texas crop is typical of that of the entire range of native pecan trees. In the Eastern States, where the pecan has been extensively planted, the orchards which have been well cared for are now bearing with fair regularity, although the species is much inclined to be an alternate-year bearer.

DATE CULTURE.

The past year has seen substantial progress toward the establishment of date culture on a commercial scale in the hot irrigated valleys of the Southwest. The large importation of offshoots of the Saidy variety secured in Egypt by an agent of this bureau in the spring of 1920 was received in California in September, 1920. A large proportion of these offshoots are now rooted, many of them well enough established to be planted in orchard form in the field. The original imported trees are infested with two dangerous scale insects and under the regulations of the Federal Horticultural Board must remain in permanent quarantine for a long period of years. In order to insure the most rapid propagation of this variety, and in order that the clean offshoots grown in this country may be avail-

able to date planters as soon as possible and at the same time protect existing date plantations against the possibility of infestation, a contract arrangement has been made for the growing of a considerable number of these imported offshoots under conditions which will insure the carrying out of the quarantine regulations and the distribution of clean offshoots produced by these mother palms. A contract has been entered into with a firm of practical date growers near Indio, Calif., whereby the original imported trees are retained in quarantine for 20 years, and the offshoots produced by them are disposed of as follows: Three-fifths are to be sold under regulations drawn up by the Department of Agriculture at a price not to exceed \$3 each for the first 10 years and not to exceed \$4 each for the second 10 years, preference being given in the sale of these offshoots to date growers living in regions suitable for the culture of this variety who do not already have more than 100 trees of the variety. One-fifth of the offshoots may, at the option of the contracting growers, either be sold under the terms just mentioned or planted by them under the same terms as the original offshoots. The remaining one-fifth of the offshoots become the property of the Department of Agriculture.

As a result of this contract a large supply of offshoots will be available each year for the next fifteen or twenty years, which can be sold to bona fide date growers at very reasonable prices.

The fact that the date palm can not be propagated by budding or grafting and can only be multiplied through offshoots produced on the mother palm in only limited numbers during the early years of its life, makes the prompt availability of an adequate stock of each variety of vital importance in establishing the date industry on a profitable commercial basis. Because of these facts, the policy of the Department in the introduction of such Old World varieties of dates has been to limit the introductions largely to such varieties as have proved under actual tests to be suited to American conditions.

New importation of Deglet Noor offshoots.—In the spring of 1921 the department secured from the Algerian Government permission to import 1,400 offshoots of the famous Deglet Noor variety. This variety is the best date that reaches the European or American markets in commercial quantities and has proved to be very well adapted to cultivation in some of the hot, dry valleys of the Southwest. Several thousand trees of this variety are now growing in this country but, as the Deglet Noor produces only a limited number of offshoots and these are often difficult to root when cut from the mother tree, the demand for offshoots is far in excess of the supply. Under these conditions the Department has brought over an additional supply which, like the Saidy offshoots imported in 1920, from Egypt, have been placed under contract with a firm of practical date growers at Indio, Calif., to be held in long-time quarantine in order to produce as rapidly as possible a supply of clean offshoots for distribution to bona fide date growers. The offshoots of the Deglet Noor variety will be distributed under practically the same conditions as outlined above for the Saidy variety except that the selling price will be not to exceed \$7.50 per offshoot during the entire 20-year period of the contract, and only three-fifths of the offshoots will be offered for sale at this price; one-fifth being taken by the

department and one-fifth going to the share of the contracting date growers who bear the entire expense of this introduction. This contract will assist in placing at the disposal of bona fide date growers a considerable number of offshoots of the Deglet Noor variety at very reasonable prices. The conditions of sale are such as to favor the planter who is just beginning to grow dates and who might otherwise be forced to pay exorbitant prices in order to get a start.

SMYRNA FIG CULTURE IN THE UNITED STATES.

The growing of the Smyrna type of fig in California is rapidly reaching the proportions of a major fruit industry. With the present rate of increase in production, the United States will soon be independent of importations from the Mediterranean regions, that reached a volume in 1920 of approximately thirteen and one-half million pounds.

The absolute dependence of this crop on a ready supply of caprifigs carrying the fig insect (*Blastophaga*) for fertilizing Smyrna figs makes vitally important the safeguarding of the caprifig supply. The distribution of caprifigs from the caprifig orchard at Loomis, Calif., under lease to the Department of Agriculture, has been a prominent factor in saving whole crops in seasons of scarcity and has saved growers thousands of dollars annually.

A scarcity of "profichi," the polleniferous spring crop, often results from winter cold destroying the hold-over or "mamme" crop. To further safeguard against this loss, arrangements are being made for a caprifig planting at some location in the bay regions near San Francisco sufficiently protected against winter cold to insure a supply of winter caprifigs to use in reestablishing the fig insect when killed out in the less protected places. There is need for other similar plantings in the foothills, both for "mamme" and for "profichi" crops.

The resistance to unfavorable weather conditions manifested by the Stanford variety, one of the Smyrna group developed in the course of the Smyrna fig investigations, makes this variety distinctly promising for future planting. The Lob Ingir, or standard Smyrna variety, often loses a considerable portion of its crop through the advent of early fall rains. The more prompt ripening of the Stanford fig prevents this loss. The Smyrna fig investigations in the Southeastern States is chiefly confined to bringing into fruit the rather numerous seedlings of the Smyrna type occurring in widely scattered communities. A limited distribution of insect-bearing caprifigs from Brunswick, Ga. (where the fig insect has been breeding in two trees for four years), has brought gratifying results in producing good crops on otherwise barren trees. The fig insect has been established also at points in South Carolina, Florida, and Texas, in addition to the first station at Brunswick. Considerable assistance in this work has been rendered by county agents, but an extended survey would doubtless bring to light large numbers of Smyrna seedlings valuable if properly caprified. A commercial planting of Smyrna figs in Florida matured some fruit this season for the first time through the use of caprifigs distributed from Brunswick.

NEW CITRUS FRUITS.

Investigations have been continued in the Gulf Coast States as well as in the Orient on varieties and hybrids of citrus resistant to citrus canker. An essential part of the campaign to eradicate citrus canker in the Gulf coast territory west of Florida is to confine future plantings to varieties known to be highly resistant to this disease. The Satsuma orange, a canker-resistant type, is the most promising commercial form of citrus for this region. The recognition that at least three varieties of Satsuma exist in the United States and several more in Japan has made important a detailed study of these varieties. The maintenance of pure stocks of the best adapted varieties, and those most resistant to disease, is vital in stabilizing the Satsuma industry. This is only possible through cooperative studies in the canker regions of the Orient, and close cooperation with leaders in the Satsuma industry of the United States. Introductions of the most promising Satsuma varieties from Japan have recently been made and arrangements perfected for giving them careful trial in Alabama.

The Thomasville citrangequat.—The stock almost universally used for Satsuma and other varieties in the Gulf coast territory west of Florida is the trifoliate orange (*Poncirus trifoliata* Sw.), a form very susceptible to canker. The Thomasville citrangequat, one of the new hybrids, has been proved entirely immune to this disease under grove conditions, and it is extremely vigorous and quite hardy. Its few-seeded character seemed to render doubtful its practical utilization as a canker resistant stock, but in February, 1921, a new method of propagating this stock was discovered which promises to make this new stock available in any desired quantities. Small twig cuttings about six inches long with the terminal leaves attached were placed in a cutting frame with bottom heat in a greenhouse where the humidity was kept high. Under such conditions, citrangequat shoots struck root promptly and without wilting of the foliage. Nearly 100 per cent of the cuttings lived and within a month they were potted. The growth of this hybrid from cuttings is so rapid that it is believed that cuttings started in early spring can be set out in the field in early summer, and then dormant budded in September, thereby saving one year over stocks raised from seed and probably making the cost of such stocks little if any more than that of seedlings, besides the advantage of absolute uniformity, both in growth and in canker resistance.

It was somewhat of a surprise to find that the citrangequat grows so rapidly from cuttings, since it is a hybrid of three distinct species (sweet orange, trifoliate orange, and the kumquat), none of which is easily rooted from cuttings.

The fruit of the citrangequat is itself proving of some value as a hardy lemon or lime substitute, making such fruits available in sections too cold for other citrus fruits. It is juicy and adapted forade making while still quite immature, filling a real need during the hot months of the summer. Its propagation is being taken up commercially and it will be given the name "Thomasville citrangequat" in a circular now ready for publication. This citrangequat first came

into notice from its being hardy enough to fruit out of doors at Thomasville, Ga. It is one of the hardiest citrus fruits that bear an edible fruit.

The Eustis limequat is fulfilling all expectations as a hardy lime for use in orange-growing sections of Florida and the warmer portions of the Gulf coast. While not as resistant to citrus canker as the still hardier citrangequat it shows considerable resistance, a character derived from the kumquat parent. This new fruit has become an accepted citrus variety, listed by several nurseries. It is chiefly recommended for home fruit gardens, but with the decline in the production of limes in Florida, due to wintertop, the limequat may become of limited commercial importance.

The tangelo.—Renewed interest has been awakened in the Sampson tangelo (a hybrid of tangerine and pomelo). It has been found especially well adapted for the fancy fruit store and mail-order trade, appealing to a considerable class who appreciate a high-flavored fruit of unusual appearance and quality. In the hands of growers who are willing to devote special attention to the production of fancy fruit, this fruit has proved profitable. The tendency of the fruit to dry out on maturity has been found to be chiefly due to budding on rought lemon stock, crops on sour orange stocks being practically free from the defect.

Siamese pummelos.—An investigation has been made of the cultural conditions under which the famous seedless pummelos of Siam are grown and introductions made of authentic plants of the best varieties. The highest quality of the Kao Pan variety of the Nakon Chaisi district seems to be maintained only in regions where the trees are irrigated with salty tidewater, and the seedless character is apparently dependent on conditions affecting pollination. Valuable data on the canker resistance of the best varieties has been secured, and these varieties will afford valuable material for hybridization and for testing in comparison with hybrids of pomelo character bred for canker resistance.

Severinia: A canker-immune hedge plant.—Among the citrus relatives, *Severinia buxifolia*, a native of South China, offers an excellent hardy substitute for the trifoliate orange so commonly used as a hedge plant and as a citrus stock in the Gulf coast territory. The eradication of those trifoliate orange hedges, regarded as absolutely necessary, will be greatly facilitated by the rapid propagation and dissemination of *Severinia*. The working out of a method for rooting cuttings rapidly promises to assist in this program, at the same time giving a uniformity in planting not attainable through the use of seedlings. This plant is also being tested as a citrus stock. Its dwarf character may make it useful in certain locations, and its absolute immunity to citrus canker recommends it.

Severinia is not closely related to *Citrus*, yet promises to be a valuable stock under some conditions. A number of other hardy relatives of citrus fruits are under investigation, and several have shown distinct promise of being valuable as stocks for the species of citrus commonly grown on a commercial scale in this country. Without question the whole problem of stocks for citrus fruits urgently demand reinvestigation from a modern botanical point of view.

COTTON.

Utilization of superior varieties of cotton.—As a result of the more careful study that has been given to cotton during the period of the boll-weevil invasion, it has been possible to develop superior varieties and improved methods of cultivation that greatly reduce the injuries or make good the losses that the boll weevil inflicts. The new varieties are better adapted to purposes of production under weevil conditions, mature earlier and larger crops, and produce longer and more uniform fiber. Several of the more prominent Upland varieties were bred and distributed by the Department of Agriculture, including Lone Star, Trice, Columbia, Durango, Acala, and Meade, and also the Pima variety of Egyptian cotton, which is grown in the irrigated valleys of Arizona and California. Millions of acres have been planted with these varieties, but this is only a beginning of the improvements that are known to be possible through general utilization of superior varieties and methods.

Such improvements of cotton production are in the interest not only of the farming communities but of manufacturers and of the public generally, since cotton is used by everybody. With better raw materials stronger and more durable fabrics can be made, and this is an economic gain as well as a commercial advantage, in our competition with the production and manufacture of cotton in other parts of the world. In view of the rapid development of textile industries in many oriental and tropical countries it is to be expected that manufacturers in Europe and America will have less need of the inferior short staples that we produce in competition with the cotton of India and China. At the same time there will be greater need of longer staples, for the fabrics of higher quality in which cotton replaces linen, silk, and wool.

Progress in one-variety communities.—The most rapid progress is now being made in communities that devote themselves to the production of a single variety of cotton under a plan of community organization that was developed through a study of the problem of maintaining supplies of pure seed, so that superior varieties might be preserved and utilized. The best example of the community plan of cotton improvement is in the Salt River Valley of Arizona, where a new branch of the cotton industry has developed within a few years on the basis of a new variety of Egyptian cotton, called Pima, that was specially bred and adapted to the local conditions. Within a few years the production of the Pima cotton increased to nearly a quarter of a million acres, with every prospect of our irrigated southwestern valleys being able to produce the supplies of fine cotton that are now being imported for the automobile tire industry. The same principle of one-variety communities is also being applied gradually in Texas, Oklahoma, and other States farther east, with the same purpose of extending the utilization of the superior varieties by increasing and maintaining the supplies of pure seed.

Centers of seed supply.—On a basis of community production of single varieties, special attention is being given to the establishment of centers of seed supply for superior varieties of cotton in different parts of the cotton belt. Local communities that adopt the one-variety plan are aided in the development of supplies of pure seed, which other communities may share, since it is dangerous to depend

too much on a single district where the seed supplies may be destroyed by unfavorable weather. Thus in 1920 the seed supplies for some of the chief centers of production of the Lone Star variety in northern Texas had to be drawn from other districts. Good seed was not obtainable, and large quantities of inferior seed and seed of other varieties were planted, which resulted in serious injury to the quality of the crop. Furthermore, the injury was not limited to a single season, because of the general contamination of good seed stocks with the mixed seed that was used widely for replanting. This shows the necessity of establishing the production of pure seed of each important variety in two or more districts, preferably far apart, to avoid the danger of simultaneous destruction of the crops by boll weevils, wet weather, early frosts, or other unfavorable conditions.

Extension of Lone Star cotton.—This is now recognized as one of the principal varieties in Texas and adjacent States. Although the chief center of production is in northern Texas, and especially around the city of Greenville, in Hunt County, where a seed-breeding station of the Department of Agriculture is located, cooperation is being given to establishing supplies of Lone Star seed in other districts, notably in southern Texas, North Carolina, Arizona, and California, in districts where the Lone Star cotton is being grown successfully.

Extension of Acala cotton.—On account of the special value and rapidly increasing popularity of this variety, the problem of seed supplies is becoming more important, not only for Oklahoma and northern Texas, but in other parts of the cotton belt. A new center of supply of Acala seed is being established in southern California, in the Coachella Valley, as a result of phenomenal yields (more than two bales per acre) secured from test plantings of Acala cotton on the Government date station, near Indio, in the season of 1920. This striking result, in addition to the generally good behavior of this variety in comparison with other Upland sorts, aroused a very active interest among the Coachella Valley farmers and led to the organization of an association for establishing an exclusive production of Acala cotton in this valley. By taking advantage of the natural isolation of the valley it appears feasible to develop and maintain high-quality seed supplies for other districts.

Extension of Durango cotton.—Several communities in New Mexico, California, and Texas are specializing on the production of the Durango cotton and developing in the direction of pure seed supplies and the exclusion of other kinds of cotton. In the Pecos Valley of New Mexico the Durango cotton has been grown in increasing quantities since 1915 and some good stocks of seed maintained through continued selection and isolation. It is from this district that the best stocks of commercial Durango seed have gone in recent years to California and to southern Texas, where Durango communities are also being established, notably in the Perris Valley, south of Riverside, Calif., and in the lower Rio Grande Valley around Harlingen, Tex. The very favorable results that have been secured from this variety in other parts of the cotton belt, including western Tennessee, northern Mississippi, southern Virginia, South Carolina, and Alabama, show that a very wide range of usefulness is possible if the necessary supplies of pure seed can be established and maintained.

Utilization of Meade cotton in the Southeastern States.—Results with Meade cotton continue to show that this specialized Upland variety is the best available substitute for the Sea Island cotton that was grown formerly in the mainland districts of Georgia and Florida, and even for the Sea Island cotton of South Carolina, if no measures can be developed for maintaining the production of the superlative Sea Island fiber from the islands below Charleston. The Meade cotton produces staple of $1\frac{1}{2}$ inches under favorable conditions, with a remarkable approximation to the strength, quality, and color of Sea Island cotton. On account of the larger bolls and more rapid setting of the crop, under conditions of weevil infestation, the Meade cotton usually yields two or three times as much as the Sea Island, or as much as short-staple Upland varieties. Utilization of the Meade cotton now depends largely on establishing a system of careful selection and isolation of seed stocks, in order to develop and maintain supplies of pure seed, and preserve the uniformity, length, and strength of the fiber. Such work is more difficult in the Southeastern States for lack of field stations or experiment farms like those that are used for cotton breeding and centers of seed supply in Texas and in the irrigated southwestern valleys.

Application of cultural improvements.—In addition to breeding and establishing the cultivation of better varieties in the districts to which they are specially adapted, general work is being done in the improvement of cultural methods. The single-stalk system of cotton culture makes it possible to control the branching and fruiting habits of the plants, so that crops can be matured in shorter periods of time. Reports of favorable results from many practical farmers as well as from local experiment stations in the cotton States have been published by many agricultural newspapers, and the popular interest and use of the single-stalk method are now extending rapidly.

Growth disorders of cotton plants.—In addition to insect pests, parasitic fungi, and bacterial diseases, it is necessary to take account of other disorders of the cotton plants that result in abnormal growth and injury to the crop. Some forms of disordered growth have been recognized in the United States, such as tomosis or leaf-cut, and brachysm or shortening of the internodes of the fruiting branches. An investigation of cotton in China resulted in the recognition of another disorder very injurious to cotton and responsible for serious reduction of the crop over a wide area of production in the Yangtze Valley. The affected plants show abnormal branching; shortening of internodes and petioles; reduction, distortion, and congestion of leaves to form dense masses of abnormal foliage, called club-leaf; and mottling of the leaf tissue with yellow or red along the margins and between the principal veins. The plants are normal at first, but the later growth is greatly deformed and discolored. After the club-leaf begins to show, all of the floral buds may be aborted, so that no more bolls are set, especially under conditions of exposure to dry hot weather. That less damage is done by the club-leaf disorder in humid districts explains why the chief centers of production of the Chinese cotton are in the coast belt.

RUBBER INVESTIGATIONS.

It has been determined that several rubber-producing plants can be grown in the United States, and a few of our native species contain gums that can be used as rubber substitutes. Many other rubber-producing species are known in foreign countries, and need to be investigated and tested to determine their adaptations for our conditions and their suitability for commercial production or for planting as reserve supplies for emergencies, either in the United States or in adjacent regions of tropical America. In view of the indispensable importance that rubber has now attained, the investigation of the possibilities of rubber production in the United States and neighboring countries of tropical America is an undertaking that can be deferred only at serious national risk. Even apart from the military danger of having supplies cut off, it is a very questionable agricultural policy to have all of the commercial rubber planting in one region. A plant disease, an insect pest, or other troubles, by suddenly reducing the supply, might inflict very serious damage on all the industries that require rubber, and these are centered largely in the United States.

TOBACCO.

An outstanding feature of the work on the nutrition of the tobacco plant is the recent discovery that a disease of tobacco known as sand-down, which greatly depreciates the commercial value of the cured leaf, is due to an inadequate supply of magnesium in the soil or fertilizer. This fact has been shown to have a very important bearing on the comparative values of potash salts and other fertilizer materials and is a factor which must be taken into account in interpreting the action of fertilizers on the plant. In particular, the ratio between the quantities of magnesium and sulphur offered the plant may be the determining factor in its normal development. Important results have been obtained in studies on the relation of temperature to the progress of certain field diseases of tobacco which throw light on the nature of the disease, their symptoms, and rate of progress. During the past season it has been possible to test on a commercial scale the effectiveness of the treatment developed by the bureau for standardizing the moisture content of cigar leaf as a means of preventing loss from black-rot during the fermentation. The results are very encouraging, indicating that the process is effective in controlling black-rot, which is the cause of heavy losses to packers every year.

FORAGE CROPS.**ALFALFA.**

A study of the day and night relations of alfalfa has thrown much light upon the range of adaptation of the various varieties and has pointed to a means of identifying the varieties in the early seedling stages. Because of their rapid growth and quick recovery after cutting, it has generally been assumed that the relatively tender varieties, such as the Peruvian and the local Kansas grown strain of common, should be used as far north as they are hardy. The evidence now, however, points to the fact that these varieties are hardy in certain sections much farther north where their optimum length

of day during the growing season gives them an advantage over the northern-grown strains, such as the Grimm, northern-grown common, and strains of *Medicago falcata*. The agronomic significance of the results obtained in connection with determining the optimum length of day of the various varieties is great.

Long-time tests of alfalfa in cultivated rows show quite conclusively that this method does not give better returns either for hay or seed than the thin broadcast stand method. Furthermore, it is an expensive method and unsatisfactory in many respects from the farmer's standpoint. Careful tests covering a period of five years have shown beyond reasonable doubt that cutting is not essential to the longevity of the alfalfa plant. Therefore, it seems safe to advise only a sufficient number of cuttings to obtain the maximum yield of hay.

SUDAN GRASS.

The acreage planted to Sudan grass has increased greatly, owing in part to an abundant supply of seed at attractive prices. The use of the grass for summer pasturage has become widespread, and this too, is a factor in the acreage increase.

SOY BEANS.

The growing area was much extended and the acreage of soy beans greatly increased during 1921. New varieties introduced and developed by the Department have been to a very large extent responsible for the increased interest in the soy bean as a general farm crop for forage, food, and oil throughout the country. Successful results with forage and seed varieties were obtained in North Dakota, South Dakota, Minnesota, the northern parts of Wisconsin, Michigan, New York, Vermont, and New Hampshire, and the southern part of Maine.

Extensive investigations with new introductions, crosses, selected pure strains, and selections were continued, including methods of seeding, culture, and harvesting, experimenting with seed of promising varieties for oil production and human food, and extension work with new promising varieties.

Selection work with new introductions from China, Manchuria, Japan, and Chosen disclosed several promising sorts. With the exception of a very few strains, all of the varieties handled by growers and seedsmen are the results of the varietal and selection work of the Department of Agriculture. During the past year the Mandarin, Black Eyebrow, Hoosier, Aksarben, and Manchu have been quite generally handled by seedsmen. The Black Eyebrow and Manchu are considered the leading varieties in many of the Northern States. The Hahto and Easy Cook as food varieties are now in the hands of seedsmen, and the demand for seed of these varieties greatly exceeds the supply. The Virginia, Peking, and Haberlandt have now become thoroughly established through the Central States, while in the Southern States the Biloxi, Laredo, and Tokio are widely grown.

In 1921 the Biloxi, Virginia, Tokio, Wilson-Five, Hahto, Easy Cook, Mandarin, Manchu, and Aksarben were distributed quite widely, and most favorable reports were received. As a summer green-manure crop for the orange orchards of California, the Vir-

ginia seems the most promising. The Haoto and Easy Cook varieties have given excellent results both as green vegetables and as dried beans. The Laredo has been found highly resistant to wilt and nematodes and has given good results on land where these diseases are prevalent. Breeding work has been continued with a large number of varieties for high oil and protein content.

Cooperative variety tests were conducted quite generally throughout the country with experiment stations and special cooperators. In many sections where the soy bean is grown to only a slight extent, time and method of seeding, culture, and variety tests were carried on.

VELVET BEANS.

The development of new early-maturing varieties and a recently evolved variety, the Bush or Bunch velvet bean, has tended to increase interest in the velvet bean and to extend the area over which it was previously grown. A wide distribution of the Bush, an entirely non-twining variety, in 1921 indicated that it is a most valuable sort for orchards in the velvet-bean region. Selection work was continued with early-maturing selections, of which many plants matured 100 per cent at Washington, D. C. Cooperative tests were conducted with nearly all of the Southern States, testing the early-maturing selections and standard sorts.

VETCHES.

The testing of a large number of vetches at certain stations in the South has indicated the areas in which the various species are adapted. Woolly-podded vetch continues to show its superior value for the Southern States on account of its comparative resistance to the disease *Protocoronospora nigricans* and its vigorous winter growth. Tangier peas have also made a heavy growth in experimental plantings and may be of considerable value as a winter green-manure crop for the southern half of Georgia, Alabama, and similar territory. The very heavy growth made by this crop in experimental plantings in western Oregon indicates its value for hay and silage.

The work has been continued with purple vetch and the seed-growing area considerably extended in California and Oregon. The regions to which purple vetch is adapted have further been demonstrated and resulted in an increased acreage in the northern coastal region of California, which promises to produce this year about 800 tons of seed. This new crop is especially well adapted for green manuring in citrus orchards of California; so this new source of seed supply is important.

Very favorable results were again secured with experimental plantings of Hungarian vetch (*Vicia pannonica*), on wet clayey soil in western Oregon. This crop will be of value for use over a large area in this region, and the commercializing of the crop is being encouraged. It produces more seed and as much hay as common vetch and is free from the aphis which causes such large damage to the latter.

Work with common vetch (*Vicia sativa*) and hairy vetch (*Vicia villosa*) has been continued with a view to making seed available at a sufficiently low figure so that farmers can afford to use these species more generally.

RED CLOVER.

Special interest was shown during the year in studies of imported and domestic red-clover seed. These tests were carried on in co-operation with the Wisconsin, Indiana, Ohio, and Pennsylvania Experiment Stations and in Michigan. Results so far secured point to the conclusion that part of the unsatisfactory red-clover crop in the United States must be laid to the account of the imported seed.

LOTUS.

The lotus plants set out on the barren hillsides in East Tennessee have maintained themselves, and some seedlings have appeared. Preliminary experiments have indicated that *Lotus uliginosus* may do well on swampy land among saw-grass. If this should prove true it will be possible to add materially to the grazing on these waste lands.

LADINO CLOVER.

This clover had shown itself so promising on the irrigated lands in Idaho that a special effort was made to establish centers of seed production.

COWPEAS.

Many new hybrid selections have given good results in comparative tests in the Southern States. The Victor, a hybrid developed by the department, proved superior to other wilt and nematode resistant sorts in extensive tests in the cowpea region.

PLANT DISEASES.**FRUIT DISEASES.**

Frost injuries to fruit trees received more than usual attention in the spring of 1921 on account of the disastrous spring frosts which destroyed the greater part of the deciduous orchard fruits while in bloom in a large belt across the eastern half of the United States. This resulted also in other necessary changes in our orchard spraying experiments.

Pear blight, while less abundant than usual in the Eastern States, continues its destructive inroads and has demanded a certain amount of attention.

Peach yellows has been more abundant than usual, and a certain amount of service work has been required for this disease.

Apple cedar rust continues an important problem in eastern orchards and was unusually severe during the season of 1920 and the spring of 1921.

Development of orchard spraying methods.—The spraying work was almost entirely confined to experiments in the peach orchards of Georgia. The results of both dusting and spraying for brown-rot control were nullified through the prevalence of the plum curculio. In cooperation with the Bureau of Entomology, every effort is being made to develop better spraying methods for the control of curculio and brown-rot.

Apple bitter-rot and blotch.—Apple bitter-rot was less destructive than usual. Blotch was, as usual, a serious disease in the Middle West, but was not more than ordinarily destructive. In the Ozarks

those following our recommendations obtained excellent control of these diseases. The field station at Bentonville, Ark., answered 2,500 inquiries, mainly concerning these diseases.

Plum and peach brown-rot.—On account of immense losses, especially in the South, peach brown-rot has received special attention during the past year. In addition to spraying experiments, studies have been made of the overwintering phases of the disease. It has been definitely proved that the perfect or apothecial stage, which is of great importance in initiating the disease in the spring, may be formed in brown-rot mummies which have lain on the ground through one winter only. Formerly it was supposed that mummies must lie on the ground through two winters before the formation of apothecia began. This discovery has a definite relation to sanitation measures recommended for the control of the disease.

Scald of apples.—The results of the studies on apple scald obtained during the past year have emphasized the value of the ventilated barrel and the hamper in storage. Apples stored in hampers have been particularly free from scald, apparently because of the openings of the package, but also partly the result of the hampers giving a more open stack in the storage room.

Oiled wrappers prepared by a commercial paper company have been completely successful in preventing scald, the apples remaining free from scald after unwrapped apples were badly scalded. A number of paper companies are preparing oiled wrappers for the coming season. About 80,000 boxes of apples will be packed in oiled wrappers at Wenatchee, Wash., and a similar number at Yakima, Wash.

Apple powdery mildew.—The results of the experiments on this disease show that complete control can be secured by the use of lime sulphur early in the season, but serious injury has resulted from later application in the sunny western districts.

Brown-rot of prunes and cherries in the Pacific Northwest.—It has been found that the brown-rot disease can be completely held in check by spraying. Also that the sprayed fruit stands up far better in shipments than the unsprayed. The more alkaline spray materials have not been found satisfactory on account of the dwarfing effect produced on the cherries.

Pineapple diseases.—The use of Natal grass in rotation to rid pineapple lands of nematodes and otherwise improve the soil has given very satisfactory results. The experimental plats that were held for two years in Natal grass sod before replanting with selected pineapple slips seem to be entirely free from the troubles that have been so serious in Florida pineapple fields, and every indication points to the production of normal crops on land so handled.

Citrus scab.—Control experiments continue to show the marked superiority of the combined Bordeaux mixture and oil emulsion spray. A professional paper has been prepared for publication covering studies on the life history of the causal organism, the conditions influencing infection, and principles underlying successful control practices.

PECAN DISEASES.

Field experiments with pecan rosette have continued to require most of the attention devoted to the pecan-disease project. The percentage of loss in certain unfavorable districts reached as high as

50 per cent of the trees. Each season's results continue to yield favorable progress in the control of the disease by adding humus-forming material to the soil. It is evident, however, that a large portion of the affected trees are on soil not sufficiently suited to the pecan to justify treatment.

Pecan scab.—Next after rosette the pecan scab, a fungous disease mainly on the fruit but also on the foliage, has demanded attention. Extensive field experiments in spraying and dusting are carried out annually. In the fall of 1920 the results of spraying with the best mixtures were not as good as expected due to an unusually late outbreak of this disease. The losses in commercial groves for the same reason were much more than usual. Dusting experiments yielded less satisfactory control than spraying. The result was a more carefully planned and larger series of spraying experiments against pecan scab in the spring of 1921.

SUGAR-CANE DISEASES.

Several diseases of sugar cane are receiving special attention. Some of these, such as the root-rot and red-rot, have been known in this country for many years and are doing much damage. Exact control measures have not yet been worked out.

The disease most recently discovered in the cane fields of the United States and the one to which most attention has been devoted is the mosaic or mottling disease of cane. This disease has been known in Porto Rico for several years and has apparently existed in Java and Hawaii for a longer period. The exact cause of this disease has not yet been definitely established. We have determined that sugar-cane mosaic is propagated through the seed cane, that it is carried from plant to plant by one or more species of insects, that it does not appear to infect the soil, and that certain varieties of cane are immune to the mosaic disease. As soon as our attention was called to this disease in Porto Rico, we began active measures looking to its control. We have found that persistent roguing will reduce the disease to a minimum. The disease on some plantations in Porto Rico has been reduced to less than one per cent of diseased plants. Last year we imported into Porto Rico from Argentina 5 tons of the immune variety, Kavangire, for seed. This has been grown and distributed to the planters in Porto Rico. Of the varieties susceptible to mosaic disease, some are more readily and more seriously affected than others. A systematic survey, covering 2,440 fields in the Southern States, was carried out during the year to determine the extent and the seriousness of the mosaic infestation in each of our sugar-cane States. All other cane diseases found were noted and specimens sent in to the laboratory. The mosaic disease is known to be present on all susceptible varieties of cane in the cane States, and it has spread to nearly all cane areas in those States. There are some disease-free areas, from which apparently clean seed may be obtained. We have discovered that in addition to sugar cane other plants, such as sorghum, corn, and several wild grasses, are susceptible to the sugar-cane mosaic, and a large amount of data has been gathered in regard to mosaic disease on these plants.

POTATO DISEASES.

The work done on potato diseases has continued to center around two main problems of national importance: (1) The control of diseases impairing the quality of seed potatoes, with particular emphasis on problems of seed inspection and certification and the production of northern-grown stock for southern use; (2) studies of potato spoilage in transportation and marketing, especially the decays of western and southern potatoes consigned to distant markets.

Potato mosaic and leaf-roll.—The mosaic disease, first brought to public attention by the department seven years ago, has been recognized as a most serious trouble and difficult of control, but recently acquired knowledge regarding its nature and manner of spread promises material relief. It is a virus disease, carried from year to year in the tubers of diseased plants and transmitted to healthy plants by insects. It must be prevented by the production of disease-free seed stocks.

Leaf-roll, until lately of unknown nature, variously attributed to unfavorable soil or weather, to "running-out," etc., is now shown to be a disease transmissible by tuber and stalk grafts and spread in the field by aphids. With leaf-roll there is frequently associated a weak sprout development known as "spindling sprout," and an internal tuber discoloration called "net necrosis," which add to the losses caused by reduced yields. Technical studies on the changes in the anatomical structure of the potato plant due to leaf-roll have led to a better understanding of the nature of the disease, and will help the field inspector to distinguish it from other confusing false leaf-rolls.

It is particularly important from the standpoint of practical control that the investigations of potato mosaic and leaf-roll during the past year have established the fact that both of these diseases are transmitted by aphids. It is believed that this is the explanation of the frequent serious occurrence of these diseases in the South in fields planted with certified seed which was thought to be comparatively free of leaf-roll and mosaic. It is evident that no field of seed potatoes can be expected to produce progeny free of these diseases if it is exposed to aphids from adjoining infested fields, and that aphis control is of primary importance in any attempt to free seed stocks of mosaic and leaf-roll infection, and experiments are now in progress, in cooperation with the entomologists, to accomplish this on a commercial scale. Steps have been taken toward the modification of seed certification standards in the light of this new knowledge. Two species of aphis were found to be capable of transmitting mosaic, but flea-beetles and Colorado beetles failed in repeated trials to transmit the disease. No mosaic infection resulted from contact of diseased with healthy plants, where insects were excluded, but both mosaic and leaf-roll have been transmitted by means of tuber and stalk grafts.

It was also proved that mosaic does not live over in the soil. Roguing under ordinary field conditions with mosaic fields near the rogued plats considerably reduced the amount of disease as compared with nonrogued stock. Eliminating mosaic plants by roguing in plats located at a considerable distance from mosaic-infested fields or in districts where aphids were less abundant resulted in reducing in one season a 10 per cent mosaic stock to less than 1 per cent, and

similar experiments with leaf-roll were even more successful. In northern Maine the Irish Cobbler variety was found to be less susceptible to mosaic than other commercial varieties grown there, but more susceptible to leaf-roll.

Potato tuber rots.—Several destructive tuber rots of western and southern potatoes have been studied in a practical way in the field and intensely in the laboratory. One confusing western decay proved to be the black-leg tuber rot, which exhibits peculiar symptoms in the West. Other hitherto poorly understood injuries have now been connected with high temperature. The general relation of temperature to potato parasites has been studied and the effect of several parasitic fungi on stems and tubers determined, so that our general understanding of potato diseases has been much clarified. The very widespread and destructive *Fusarium* blight has been shown to infect the plant through cut seed pieces. Possible relief by using whole seed is suggested.

Sweet-potato diseases.—Methods for the control of black-rot and related diseases of sweet potatoes spread from the plant bed were developed by previous work of the bureau. Attention is now concentrated on storage rots, perhaps the greatest source of loss to the sweet-potato crop. These investigations have made marked progress during the year, and the results secured have greatly increased our knowledge of the factors influencing decay in storage. The most important of these is wounding. It has been found that perfectly sound potatoes may be held at almost any range of temperature and humidity with safety, but in commercial practices wounding invariably occurs and furnishes an avenue for the entrance of storage-rot organisms. Physiological studies that have been made, both of the sweet potato and of the various organisms causing decay in storage, have revealed the manner in which infection is accomplished. Although the initial germination and growth of these fungi may take place on sound tissues, it has been found that infection usually occurs only where dead tissue is present to give it a saprophytic start. The fungus progresses through the live tissues of the potato by the secretion of a substance that is of the nature of a ferment, which acts in advance of the growth of the organism and kills the tissues. It was found that wounds made in the process of harvesting are covered by a protective cork layer, if the potatoes are subjected to a sufficient degree of moisture, and that this acts, to a considerable extent, as a barrier against the entrance of decay-producing organisms, thus explaining the fact that many wounded potatoes are stored which do not decay. However, wounds made after the potatoes have been harvested for some time, especially after they have been placed in storage, are not so protected and almost always lead to decay, very slight wounds being sufficient to permit of infection if the humidity is sufficiently high.

Studies of the temperature relations of the various organisms causing storage rots have shown that some of these are able to infect sweet potatoes at the temperatures at which storage houses are usually maintained. The most important of these is *Rhizopus nigricans*, but 10 other species of *Rhizopus* have also been found to cause rot in storage.

CUCUMBER MOSAIC DISEASE.

Investigations of cucumber mosaic have made definite progress during the past year. It has been established that the wild cucumber carries the mosaic disease over winter in the seed, and it has been found that districts in which the disease is common on the wild cucumber usually suffer heavier losses from mosaic on cultivated cucumbers. The common milkweed, a perennial, also has been shown to carry the disease over winter, and it has been demonstrated that it acts as a source of early infection to the cucumber, although of less importance in this respect than the wild cucumber. Attempts to control mosaic by the eradication of the wild cucumber have given encouraging results, and it is believed that the combined eradication of the wild cucumber and milkweed may offer a practical means of control. The rapidity and severity of the development of mosaic have been found to be related to soil and air temperatures, a temperature of 30° favoring infection and the rapid development of the disease, while temperatures below 20° C. seem to retard or entirely prevent its appearance. Some variation in the resistance of cucumber varieties to mosaic was shown in comparative tests. A step in the control of cucumber mosaic is the withdrawal of seed of the wild cucumber from the trade, which is assured through action taken by the Seed Trade Association at its recent meeting at St. Louis, at the request of this bureau. Cucumber mosaic is serious and widespread in the large pickle-growing areas of the Middle West, and the discovery of methods for its control is therefore a distinct contribution to the progress of the industry.

TOMATO DISEASES.

Nailhead spot is shown to be capable of attacking only immature fruit, consequently all its injuries are traceable to the field and must be prevented by spraying. Phoma fruit-rot develops almost entirely in transit and requires special treatment or preripening methods not yet perfected. Various soil rots come from soil infection in the field and are preventable by methods of culture, sorting, careful handling, and preripening.

ONION DISEASES.

An extended investigation of onion smudge was completed within the past year. It was shown that present methods of growing and handling onion sets in the set-growing districts in Wisconsin and Illinois are conducive to the excessive development of this disease and that the artificial drying of the sets immediately after harvest, together with the provision of well-ventilated storage at about 33° to 36° F., will control the disease. Resistance to smudge was found to vary with color, white varieties of onions being very susceptible, while the red varieties were resistant. Studies to determine the influence of soil moisture and soil temperature upon the development of onion smut were also completed during the year. High soil temperatures were found to greatly retard the development of this disease.

THE PRODUCTION AND DISTRIBUTION OF YELLOWS-RESISTANT CABBAGE SEED.

Arrangements were made during the past year by this bureau, with the cooperation of the University of Wisconsin and associations of commercial growers and packers, providing for the production of a

continuous supply of yellows-resistant cabbage seed, to be made available to the growers of all sections where this type of cabbage is needed. The prospects are now good for a large crop of seed of the resistant All Seasons variety for planting in the season of 1922. Resistant strains of other varieties, including Hollander, Brunswick, All Head Early, and Copenhagen Market, have been bred and will be propagated for distribution in the near future.

MARKETS PATHOLOGY.

The spoilage of vegetables in transit and marketing is due in large part to plant diseases, and the food-products inspection of the Bureau of Markets must therefore be able to distinguish with accuracy all the types of decay and injury met in the markets, and this training is given by our pathologists, who must themselves make special studies of the new problems constantly arising in the losses of perishable vegetables. For this purpose working laboratories have been maintained in New York and Chicago and field conditions studied in various producing centers, especially west and south. The training which makes it possible for the inspectors to analyze the loss in a given shipment, attributing wastage to definite diseases, which they name on the inspection certificates, has also been found of value to the carriers or distributors who request the inspection.

CORN ROOT, STALK, AND EAR ROTS.

It has been found that sweet corn as well as field corn suffers heavily from corn root, stalk, and ear rots. On both, these troubles are widespread and the combined losses are enormous. The symptoms are very similar in both sweet corn and field corn and in general represent lowered vitality due to the attacks of the diseases. Among the early symptoms are rotted kernels and dead seedlings, which later in the season the chief symptoms are missing hills, stunted plants, barren plants, nubbins, broken plants, broken ear shanks, diseased ears, and plants which blow over in large numbers during storms because of rotted roots and rotted stalks.

The chief fungous parasites are *Gibberella saubinetii* (the wheat-scab fungus), different species of *Fusarium*, especially *Fusarium moniliforme* and *Diplodia zae*. It is now definitely proved that certain soil conditions, especially acidity or a lack of lime and sometimes of phosphorus, have a profound influence on the growth of the corn plant which may make it especially susceptible to attacks of these fungi.

ACCUMULATIONS OF IRON AND ALUMINUM IN THE CORN PLANT.

The abnormal functioning of corn plants associated with the deposit of harmful metals, noted last year, has been made the subject of extensive and critical research. It has been determined that the chief toxic metals accumulating in the plants are iron and aluminum, both of which normally are present in large quantities in most corn-belt soils. Injection experiments with these and many other metals and many organic acids show conclusively the toxic effect of iron and aluminum in the corn plant under certain conditions. These

metals are deposited in the tissues of the vascular plate at the nodes of the stalk, and disintegration of those tissues follows rapidly. The same effect is produced in the nodes of the ear shank, resulting in poor ears.

Some corn plants apparently have a specific selective capacity for the absorption of these metals when they occur in the soil in subtoxic quantities. When the concentrations in the soil are higher, however, this selective capacity apparently can not be exercised. Abundant available phosphates precipitate soluble aluminum salts. The application of lime and especially of lime and phosphates to soils in which definite metal injury occurs has proved decidedly beneficial in controlling such injury. Evidently the corn plant sustains a twofold injury (1) direct injury from these toxic metals, and (2) a greater injury from the root-rot organisms because of greater susceptibility to their attacks when injured by metallic deposits.

The planting of diseased seed may be avoided by using the improved rag-doll germinator or improved type of table germinator and by careful field selection and storage of the seed ears. Attention to the destruction of old corn stalks where wheat follows corn and of wheat refuse where corn follows wheat will serve to hold in check the organism which causes both corn rot and wheat scab. Treatment of acid soils with lime or lime and phosphorus greatly reduces metal injury and consequently the susceptibility of the plants to the attack of the rot-producing fungi.

FUSARIUM BLIGHT, OR SCAB, OF WHEAT AND OTHER CEREALS.

Fusarium blight, or scab, is able to attack corn as well as the small grains, and furthermore this disease has two important phases on these various hosts: (1) The attacks on underground parts, beginning with the seedling blight, and (2) the attacks on the parts above ground, chiefly the heads, producing head blight, or scab, in the case of wheat and other small grains. The same fungous parasite, *Gibberella saubinetii*, is the common cause of both the seedling blight and head blight, or scab. In previous estimates of losses, the injury from seedling blight has not been included. The seedling-blight phase of the disease has been found to be important in both winter and spring wheats. The seedling blight may result either from the use of infected seed or from sowing clean seed on infested land. It has been found that the amount of injury is greatly influenced by soil temperature and soil moisture. Low soil temperatures inhibit seedling injury in wheat, but in corn the reverse is true. The fungus grows well over a wide range of temperatures, and hence the indications are that the effect of the different soil temperatures, both in wheat and in corn, is on the host-plant rather than on the parasite. Wheat, a cool-weather plant, is able to resist the attacks of the parasite best at the lower temperatures, while in the case of corn, which is a warm-weather plant, the reverse is true.

It has been found that a low moisture content of the soil accentuates the injury from seedling blight on both wheat and corn.

Recent investigations have verified previous finding that the fungus *Gibberella saubinetii* is the chief offender in causing head blight, or wheat scab. It has been found that the chief source of infection is from old crop refuse, particularly old stubble or cornstalks, on which

the parasite overwinters. It has been found that infection takes place at or immediately following the flowering period and that, with the organism present, the weather conditions during this period determine the amount of injury from head blight, or scab. Dry weather through this period inhibits the development, while moist weather favors it.

Most complete control of the seedling blight of wheat has been obtained by the use of clean seed, or of seed thoroughly cleaned and then treated with formaldehyde, sown when the soil is cool. This requires late-sown winter wheat and early-sown spring wheat. Crop rotation combined with thorough covering of crop refuse by careful plowing is very important in controlling head blight, or scab.

TAKE-ALL DISEASES OF WHEAT.

Investigations have shown that there are in the United States at least two distinct diseases of wheat which have certain outstanding similarities, particularly in regard to the way infested wheat fields are affected. It has been found that the disease, previously tentatively called take-all, reported from Illinois and Indiana, is not the true Australian take-all, as the latter is now understood. Hence, for want of a suitable name, this Illinois and Indiana disease is called so-called take-all. True take-all, caused by the fungus *Ophiobolus graminis*, identical with the Australian disease, also has been found in a number of States during the year.

NEMATODE OR EELWORM DISEASE OF CEREALS.

This disease has recurred in Virginia and West Virginia, but with less destructiveness than previously. Farmers have been quick to put into practice the control measures developed in these investigations and thus have greatly reduced their losses. In Georgia the disease is almost eradicated. The disease has been found in North Carolina and is rather destructive on some farms. It has not yet been found in Ohio, where previously suspected to occur.

Recent investigations conducted in cooperation with the Wisconsin Agricultural Experiment Station, at Madison, Wis., in a carefully fenced area, have shown that the disease will develop there on winter wheat when the nematode galls are sown with the seed in the fall. In these experiments it also has been found that certain spring-wheat varieties are virulently attacked when the nematode galls are sown with the seed in the spring. This tends to show that the disease should be guarded against in the spring-wheat sections as well as in winter-wheat regions.

STRAIGHTHEAD OF RICE.

Investigations have shown that the disease is nonparasitic in nature, caused by insufficient aeration of the roots during certain stages of development of the rice seedlings, on certain types of soil, especially on virgin soil and soil where nonirrigated crops have been grown. This results, first, in an abnormal development of the root systems and, later, in the development of sterile "straight" heads.

On soils where the trouble is likely to develop, it can be prevented by draining off the water during irrigation for a period of 2 to 3

weeks to permit the aeration of roots necessary for the proper development of the rice plants.

SEEDLING BLIGHT OF RICE.

An important seedling blight of rice was found to occur at Crowley, La. Investigation showed it to be caused by a fungous parasite, *Sclerotium rolfsii*, known to attack various crops and wild grasses. A closely related strain was found attacking soy-bean plants. This disease attacks the roots of young rice seedlings and is checked as soon as the irrigation water is applied. Early application of water is recommended where the disease is developing.

STEM ROT OF RICE.

This trouble, previously described from Italy and Japan, was noted in the United States, at Crowley, La., for the first time. The disease is caused by a fungous parasite, apparently *Sclerotium oryzae* Catt., which attacks the interior of the developing rice stems at the surface of the irrigation water. The stems of attacked plants weaken and break over, and the heads of such plants fail to mature normally. The fungus is spread by water and may be carried also in straw. The Japanese, or short-kerneled, rices apparently are less susceptible than the long-kerneled varieties, and it is hoped to develop more resistant strains.

THE DOWNY MILDEWS OF MAIZE IN THE PHILIPPINES.

Further research has shown that the Philippine downy mildew of maize involves two conidial *Sclerosporas* as causal organisms; *Sclerospora philippinensis* Weston occurring on maize, sorghum, and teosinte in the northern Island of Luzon, and *S. spontanea* Weston occurring on maize, sugar cane, and *Saccharum spontaneum* in the Visayan Islands at the south. These two species have been carefully compared in the shape and size of their conidia and conidiophores and in their virulence and range of hosts, and the differences between them have been established by detailed study. The reaction of a large number of varieties of maize and of several related plants to these *Sclerosporas* has been worked out, and the problem of susceptibility to and immunity from them has been studied. The structure and biometric characteristics of the oogonial *Sclerosporas* on wild grasses, which are apparently related to the conidial stages, have been worked out, and the probable affinities of these oogonial forms to other *Sclerosporas* of the Orient and Europe have been investigated.

Means for controlling the disease have been devised and successfully put into practice on a small scale. The procedure involves: (1) The removal of sources of infection in the near vicinity before planting; (2) the planting of fields at one time in one region; and (3) the immediate destruction of such few plants as may become infected during the first weeks of growth, when maize is most susceptible.

THE DOWNY MILDEW OF WHEAT IN THE UNITED STATES.

This disease, hitherto unknown to the United States, has been found in Jackson and Obion Counties, Tenn., and in Fulton County, Ky., while specimens in the pathological herbarium at the California

Agricultural Experiment Station show that it was present in Kings County, Calif., in May, 1919. In our country, as elsewhere, the disease is known only in its oogonial stage.

A preliminary study in Tennessee and Kentucky has shown that the disease is restricted almost entirely to low-lying, poorly drained fields, or parts of fields in which the young seedlings of winter wheat have been subjected to excessive moisture. The general indications from field conditions in the infected districts are that the disease is not of sudden or recent appearance, but has been present for many years. The disease is found not only on the three or four varieties of soft red winter wheat which are grown in these localities, but also on *Bromus commutatus* Schrad., a grass similar to "cheat" and very common both in the wheat and around field borders. On this grass the disease was found quite independent of wheat, occurring along a railroad track about a mile from the nearest and quite healthy wheat fields.

The losses occasioned by this disease on wheat in the western Tennessee and Kentucky district apparently are slight. In wet, poorly drained localities which favor the disease, large numbers of plants are affected and destroyed, but as such poorly drained areas represent a very small proportion of the whole district, and as the disease is closely restricted to such localities, the total loss is not very great. This loss is persistent, however, for the fungus survives between wheat crops on *Bromus* or in the soil, and continues year after year, crop after crop, taking a toll which, although slight, represents a considerable loss in the aggregate.

Unfortunately, no really practical suggestions for control can be made as yet. Various attempts to diminish the disease have been made in Europe, but with little success. The obscure life history of the causal *Sclerospora* is being studied in order to secure a basis for effective methods of control.

BUNT OR STINKING SMUT OF WHEAT.

Physiology of bunt germination and infection.—An extensive investigation of the factors governing the germination of bunt spores and their infection of the wheat plant has been completed. Studies of spore vitality show that they may live for several years if kept entirely dry, that they will remain alive in the unbroken smut balls in the soil for months, at least up to a year and a half, but when the spores are free in moist soil they lose their vitality in 30 to 60 days.

The optimum temperature for germination is 18 to 20° C., but germination may occur at temperatures from 1° C. to about 28° C. The fungus may enter the seedling at any point along the coleoptile and may occur until after the first leaf is developed.

The spores of bunt are carried broadcast by wind during harvesting and thrashing operations and adjacent summer-fallowed fields are deluged with them just before fall seeding of wheat takes place. Experiments show that replowing this summer fallow before seeding buries the spores below the level of the seedbed. Infection will be prevented also if the seed is sown before the smut showers begin, or if seeding is delayed until after the spores have died in the moist soil. Infection from soil-borne spores is partly controlled when the seed is treated with copper sulphate or copper carbonate, but not when formaldehyde is used.

LEAF SMUT (FLAG SMUT) OF WHEAT.

Investigation of this disease is partly cooperative with the Illinois Agricultural Experiment Station.

Distribution of leaf smut.—Leaf smut of wheat has been found to be more widespread in 1921 than in 1919, when it was first reported, and in 1920. In 1919 it was found in Madison County only, in 33 fields comprising about 825 acres. Usually only a trace of the disease was present, although occasionally as much as 1 to 2 per cent was found. Last year the leaf smut, while confined to Madison County, had spread to 111 fields, comprising about 2,500 acres, in an area of approximately 47 square miles. Usually the percentage of infection was low, but in parts of some fields it ran as high as 15 to 20 per cent.

In 1921 the disease has continued its spread in Madison County and also has appeared in St. Clair County, adjacent on the south. In Madison County it was found in 211 fields on 121 farms, an increase of 100 fields, but of only 3 square miles, over last year. In St. Clair County the leaf-smut area contains 50 infested fields on 28 farms, totaling 2,916 acres.

Losses caused by leaf smut.—Leaf smut is not causing the farmers an appreciable loss, as less than 1 per cent was found this year in all but 10 fields. In a few fields, however, spots were found where as high as 10 per cent of affected plants occurred, and in one field an average of 15 per cent was recorded, showing that it can become destructive under conditions existing in western Illinois. Comparison of records of infection in 1920 and 1921, on the same farms, shows in general that it was no more destructive this year than last, and in some cases less.

Control measures.—The quarantine of the infested areas is maintained by the State Department of Agriculture of Illinois. The regulations provide (1) for the disinfection of harvesting and thrashing machinery used in infested fields, (2) for the disinfection of thrashed wheat, (3) for restriction in the use of the straw, and (4) for the sowing of only resistant varieties. Experiments to test the effectiveness of different chemical agencies for treating thrashed grain have shown none as desirable as formaldehyde.

In the fall of 1920 all seed wheat (about 15,000 bushels) sown in the quarantined area was treated with copper sulphate (blue vitriol) and lime before seeding. Small percentages of smut were found in some of the fields sown with this treated seed, due probably to infestation of the soil by spores distributed by the wind or other agencies. So much of the farm land in that district is sown to wheat that control by crop rotation probably is not possible because of wind-blown spores.

Results of continued experiments on varietal resistance show that several well-known varieties adapted to that section show a very high degree of resistance to leaf smut. Among these resistant varieties are such widely grown and valuable wheats as Fulcaster, Gypsy, Early May, and Turkey. By means of these, it is hoped to hold the damage caused within low limits and perhaps to eradicate the disease entirely.

BLACK STEM RUST OF WHEAT AND OTHER CEREALS.

Research on this widely distributed and oftentimes very destructive disease has been conducted in cooperation with the agricultural experiment stations of Minnesota, Kansas, and California, as well as in the department laboratories.

The epidemiology studies, designed to determine the time and source of first infections in the spring, have been conducted on an intensive scale over large areas. Three chief phases of the problem were studied. (1) beginning of infection in the Southern States, (2) the beginning of infection in the still-infested portions of the States comprised in the barberry-eradication area, and (3) the beginnings of infection in that portion of the eradication area from which barberry bushes have been removed. Rust specialists were sent into the far South in early spring to study the advent of rust on grasses and cereals and to trace the spread of rust northward with the advance of the season. The search finally led into northern Mexico, where stem rust was found in great abundance. As the season advanced, rust appeared in the northern wheat-growing States. In a great majority of cases the beginnings of outbreaks were easily traceable to barberry bushes. Of the local rust outbreaks which appeared up to June 30, 1921, in those portions of the barberry eradication area supposedly entirely clean of bushes, a great majority had been traced to occasional overlooked bushes or to sprouts and seedlings which had developed since the original bushes were dug.

BARBERRY ERADICATION.

A campaign for the eradication of the common barberry in order to control the black stem rust of wheat was begun in the spring of 1918 and is now in its fourth year. The eradication area comprises 13 of the north-central wheat-growing States, namely, Colorado, Illinois, Indiana, Iowa, Michigan, Minnesota, Montana, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin, and Wyoming. All of these States now have enacted legislation requiring the removal of common barberry bushes. The campaign is conducted in co-operation with the State agricultural college in each of the States and with the State department of agriculture in most of them. The three different phases of the campaign, namely, education, location, and eradication, have been continued throughout the year in each State except Montana, where the original survey has been completed and only a small amount of resurvey is required.

Education comprises the distribution of literature, including posters, bulletins, circulars, form letters, post cards, cartoons, etc., the preparation of articles for State and county newspapers and farm journals; the giving of talks in schools, at farmers' organizations and other public assemblies, and the circulation of 15 motion-picture reels. Since the beginning of the campaign, approximately 100,000 posters, 175,000 bulletins, 150,000 circular letters, and more than 50,000 copies of other literature have been placed in circulation.

The farm-to-farm survey to locate barberry bushes has been pushed vigorously during the year. At the end of 1920 the equivalent of 183 counties had been cleaned in this way. During the spring the

number has been increased to over 200, leaving about 600 yet to clean. A continuous resurvey also is in progress to determine what bushes located previously have not been eradicated by the property owners and also to locate sprouts developing from roots of bushes not properly dug, and seedlings developing from berries scattered in digging or by birds. A second resurvey is essential and, in many cases, a third also. From the beginning of the campaign to the end of 1920 barberry bushes have been found on about 45,000 properties. The total number of bushes found was approximately five and one-half millions. Of these, about 2,000,000 were found in cities and towns, practically all of which have been surveyed, and three and one-half millions in the country, of which about one-fourth has been surveyed. Of the approximately three and one-half million bushes found in the country, about 3,200,000 have been escapes from cultivation, scattered by birds and other animals.

Most of the bushes located to date have been destroyed. The great majority of these are removed willingly by the owners and only in rare instances do State officials have to resort to the authority given them under law to compel eradication. Of the approximately five and one-half million bushes located, about 4,200,000 have been removed. Of the remainder, about 1,000,000 are bushes less than 18 inches in height on a single farm in Grant County, Wis. Of the numbers removed, about 1,400,000 were destroyed by owners of nurseries in the early days of the campaign.

The counties cleaned in the different States by the farm-to-farm survey form two rather large contiguous regions and several smaller ones. The largest of the contiguous areas covers the western portions of Iowa and Minnesota and the adjacent eastern portions of Nebraska and the Dakotas. Montana has been completely covered and it is expected to complete Colorado this season.

CROWN RUST OF OATS.

The investigation of crown rust of oats is conducted in cooperation with the Iowa Agricultural Experiment Station.

Investigation of the several species of *Rhamnus*, or buckthorn, occurring in this country shows that two species, *R. cathartica* and *R. lanceolata*, are important factors in the development of epidemics of crown rust in Iowa and adjacent States. Material of little-known western species of buckthorn has been obtained for study.

The wild grasses which also are hosts for this rust are being investigated and many have been found to be susceptible. Study has now been started to determine (1) whether or not the crown rusts occurring on various grasses, especially *Bromus*, in the Rocky Mountain region, are different biologic forms of the common rust of oats and (2) the relationship of the buffalo berry and wild olive to this rust, of which they are suspected to be alternate hosts.

In the oat-breeding nursery two varieties, Green Russian and White Russian, have been found resistant to crown rust and have been used in crossing with many of the leading commercial varieties. The hybrid progeny is being selected to develop high-yielding resistant strains of good quality.

FOREST PATHOLOGY.

WHITE-PINE BLISTER RUST.

White-pine blister rust is a destructive plant disease introduced from Europe into the United States on white-pine nursery stock during the past 20 years. It was first found attacking native pines during the fall of 1915 in Massachusetts and New Hampshire. At present it is generally distributed in New England and New York, and is established over a large area in Wisconsin and Minnesota. In these States it is impossible to eradicate the disease. Two local infections were found on black currants in New Jersey in 1920.

In the eastern white-pine region, the blister rust can be controlled by eradicating all wild and cultivated currant and gooseberry bushes within 200 to 300 yards of the pines. This work is practical and effective. The native pine in diseased areas is fast becoming generally infected, and it is essential to secure the general application of control measures to prevent great loss from this disease.

The shipment of blister rust host plants in violation of Federal and State quarantine regulations is a constant source of danger to the extensive five-needled pine forests of the Western United States. Conditions in the West are favorable for the rapid spread of the blister rust and once established it would cause immense loss to public and private holdings of five-needled pine. To protect this valuable resource it is necessary to make every effort to prevent the movement of five-needled pine, currant, and gooseberry plants into the Western States in violation of quarantine regulations.

Cooperation in blister-rust control.—Formal or informal cooperation has been established with all States except Florida, Alabama, Mississippi, and Louisiana, where there are no five-needled pine interests. Scouting is done in Western States where the presence of forest reserves and the distribution of five-needled pines make the danger of infection from suspicious shipments of blister-rust host plants most serious. Nursery shipments of five-needled pines, currants, or gooseberries known to be or suspected of being infected or which are shipped in violation of Federal quarantines are traced and reported to the State authorities for action. In the Central and Great Plains States assistance is given the Federal Horticultural Board in adequately enforcing quarantine No. 26, which prohibits the shipment of five-needled pines, currants, and gooseberries west of the quarantine line, which extends along the western boundary of Minnesota, Iowa, Missouri, Arkansas, and Louisiana. Special emphasis is given to preventing the introduction of the disease into the Rocky Mountain and Pacific Coast States through illegal shipments of blister-rust host plants.

Control of blister rust in the East.—White pine is the most valuable tree for crop production in the Northeastern and Lake States. It makes rapid growth, has high stumpage value, and produces returns of from \$3 to as much as \$10 per acre per year. Since the cost of applying control measures amounts to only a few cents per acre per year, it is financially profitable for owners to protect it from blister rust. The cut of eastern white-pine lumber is valued in excess of \$50,000,000 per annum, and the present merchantable stand

is estimated to be worth \$276,000,000. Extensive damage to white pine is occurring in the best pine-growing sections of northern New England and New York. This was anticipated, but the present extent and severity of damage was not expected to be apparent for the next six to eight years. Damage from blister rust is cumulative; that is, light infection of currant and gooseberry bushes causes corresponding light infection in adjacent pines. As more pines become diseased, the currant and gooseberry bushes become more heavily infected, and in turn cause greater destruction of pine. The general application of demonstrated methods of local control in infected regions is necessary to prevent enormous loss in pine stands and insure the future production of this valuable crop.

Damage to pines.—Rod-wide strip surveys, totaling 138 miles in length, were conducted during the past two seasons over extensive areas in New England and New York. In addition, a survey was made of 256 plats adjacent to the strip lines. A total of 53,838 pines were examined, and 8,620, or 16 per cent, were already diseased. The rapidity with which pine infection is taking place will increase with each succeeding year as the intensity of the disease becomes greater on its host plants. The first wave of infection has passed over the northeastern white-pine area. Another wave, greatly increased in volume and severity, is now developing on the pines, as shown by recent observations at many points. When these diseased trees produce spores abundantly, it is certain that succeeding waves of infection will cause the complete destruction of pines over extensive areas.

In stands under 10 years of age the disease strikes heavily and kills quickly. This means that young pine growth can not be raised to useful size while exposed to infection from adjacent currant and gooseberry bushes. Severe damage is now occurring in stands up to 20 years old, and considerable loss will occur in stands now between 20 and 30 years of age. The rust strikes heavily at the dominant trees and takes an increasingly larger number each year. In most cases, stands now over 30 years old will be harvested within the next 20 years and probably can be cut before the disease has caused an appreciable loss in timber. White pine reaches commercial maturity at about 50 years in New England and New York. For highest quality timber, longer rotations are required, and the probability of damage from the disease is increased.

Within infected areas it is a case of choosing either white pine or currant and gooseberry bushes. There is no alternative. This problem must be faced at once and if the pines are to be saved, currant and gooseberry bushes must be eradicated on a much larger scale than has been done up to the present time. In Northern Europe the growing of white pine as a forest tree has been abandoned because of the severity of the disease. This emphasizes its serious nature and power of destructiveness.

Ribes eradication.—Since beginning local control work in 1917, practical methods have been successfully developed for the control of this disease in the eastern white-pine region by the eradication of currant and gooseberry bushes.

The average cost of control, in spite of war wages for labor, has been reduced from 66 cents per acre in 1918 to 54 cents per acre in

1919, and 35 cents per acre in 1920. In New England the cost was 24 cents per acre, in 1920, on 260,018 acres. These figures include the cost of labor, supervision, and transportation of field men.

The efficiency of control work in 1920, as determined by 682 checks on areas totaling about 6,000 acres, shows that an average of 97.2 per cent of the total number of currant and gooseberry bushes were destroyed in the first working of the ground. The few bushes missed are small and well hidden as a rule, and therefore, not a serious menace for several years. Currant and gooseberry bushes do not reappear rapidly in an area worked by an efficient crew. Where the bushes are very numerous the ground should be reworked in about five years. In other sections 8 to 10 years can elapse before the second working. In all, 936,102 acres of forest land have been cleared of 13,249,004 currant and gooseberry bushes since 1917, thus protecting the standing white pine on this area and making it safe for the future production of this crop.

CITRUS-CANKER ERADICATION.

As a result of the vigorous eradication campaign conducted by the Gulf States in coöperation with this bureau, citrus canker, a bacterial disease of citrus trees, has been practically eliminated from the greater portion of this region. Alabama, Mississippi, and Florida are free from any general infection, but it is probable that scattered cases will be found in them for one or more years, and scouting to locate and remove such cases promptly must be continued. Louisiana apparently has eradicated canker from the commercial producing area, but many scattered infected trees are being found in isolated places.

Effective eradication activities are now under way in Texas, and it appears that by far the larger part of the infected trees have been located and removed. Occasional outbreaks of canker occur in the lower Rio Grande Valley—and at the present time major efforts are being devoted to the thorough eradication of canker from the entire Rio Grande district.

POISONOUS PLANT INVESTIGATIONS.

Field studies on plants poisonous to live stock have been continued, chiefly in the Gila and Datil Forests in New Mexico, and in the Apache, Coconino, and Tusayan Forests, Ariz. Many poisonous species have been located on the grazing areas of these forests and their identity and distribution indicated to local stockmen.

Baccharis pteronoides was found in abundance in the Gila Forest and is a serious menace to grazing herds. Its occasional occurrence was also noted in the Datil and Tusayan Forests.

Evidence has been accumulated indicating that the so-called "pingué" poisoning of sheep is caused by *Gutierrezia sarothrae* as well as by *Hymenoxys floribunda*, the plant known to stockmen as pingué.

Work has been continued on distinguishing annual from perennial species of loco. This information is essential to the work of eradication, since annual species can be controlled by preventing seed

formation, while the growth of perennial species can be controlled only by removing the root crowns from the soil by digging.

Further progress has been made in identifying the numerous species of loco. Since it has been definitely proved that many of the loco plants are not poisonous, the establishment of the identity of the poisonous species is essential in order that in the work of eradication labor may not uselessly be expended by removing the harmless species.

Field work, in cooperation with the Virginia Agricultural Experiment Station, on species of *Dicentra*, known locally as "little stagger weeds," has yielded important results. *Dicentra cucullaria* has been definitely shown to be poisonous to cattle and to contain a new and highly poisonous alkaloid. A report on the poisonous properties of this plant and the characteristics of the new alkaloid will soon be ready for publication.

Information secured through the Maryland Agricultural College regarding an unknown plant suspected of causing the deaths of sheep led to a field investigation on the Eastern Shore of Maryland, where the plant was identified as *Ornithogalum umbellatum* and evidence obtained of its poisonous action. A highly toxic substance prepared from this plant has been provisionally determined as a glucoside.

IRRIGATION INVESTIGATIONS.

THE CAUSE OF HARD LAND.

The most important result of the investigational work of the past fiscal year has been the discovery of the cause of the hardening of irrigated lands. This problem has been very serious in many sections of the irrigated West. In some cases desert soils suitably located for irrigation have been found to be so impermeable to water as to be unsuited for crop production. In other cases lands that have been irrigated for a few years have become increasingly hard and difficult to get into good tilth, and, in consequence, have become unproductive. In extreme cases it has been found necessary to abandon lands that only a few years ago were highly productive.

As a result of the investigations referred to, it has been found that this hardening of the soil is primarily due to the action of salts of sodium carried in the irrigation water and that the difficulties described occur in cases where the proportion of the soda salts in the irrigation water is relatively high as compared with the salts of calcium. While the field investigations of this problem are not yet completed, the indications are that it is possible to prevent the injury caused by the sodium salts through corrective applications of salts of calcium, iron, or aluminum, and it may be found practicable to reclaim and bring into profitable production areas of land that have been abandoned because of injury from sodium salts.

CROP-ROTATION INVESTIGATIONS.

The investigations in irrigated crop rotations conducted at the three field stations operated by this office in the northern Great Plains have continued to give striking results in the way of showing the beneficial effects of the use of alfalfa in rotations, and of

the occasional use of farm manures. These experiments make it clear that even on the rich virgin irrigated lands of the West a systematic rotation of crops and the maintenance of live stock in order to obtain farm manure is essential in order to secure the larger crop yield without which successful farming can not long be carried on.

CROP UTILIZATION.

In view of the importance of maintaining live-stock industries on irrigated lands, not only as a means of utilizing profitably the bulky forage crops which may be produced abundantly and cheaply on these irrigated lands but also as a means of maintaining high production of such cash crops as potatoes, sugar beets, and cotton, through the use of farm manure, attention has been given to the problems of crop utilization through the use of live stock. Extensive and successful demonstrations have been conducted in the use of pasture crops for cattle, sheep and hogs, in the production of silage crops, and in the most efficient methods of supplementing pasture crops with grain for the economic production of meat and milk.

FIBER-PLANT INVESTIGATIONS.

FIBERS FOR BINDER TWINE.

The progeny of 15 sisal plants and 15 henequen plants selected for their superiority over others at Mayaguez, P. R., in 1917, now number thousands of plants of selected stock from which all inferior plants are discarded.

Demonstrations with fiber-cleaning machinery in cooperation with the Philippine Bureau of Agriculture have given practical results. In 1918 there were no fiber-cleaning machines in the Philippine Islands. In the spring of 1921 there were 12 machines in operation, 4 machines being installed, and 2 machines in storage ready to be shipped out to plantations. An agency for fiber-cleaning machines has been established in Manila. The superiority of machine cleaning over water retting and hand cleaning is now generally recognized. In the first five months of 1921, 2,219 bales of machine-cleaned sisal and maguey fiber were produced in the Philippine Islands, compared with 176 bales in the first five months of 1920. The total daily capacity of the machines now in operation or being installed is approximately 48,500 pounds of fiber.

FIBER FLAX.

The principal efforts in the work with fiber flax have been to increase the supply of seed of the best selected strain which has been demonstrated by repeated tests to be superior to commercial fiber flax. This variety, called "Saginaw," has been developed by repeated selection and careful roguing since 1909. Previous efforts to increase the seed in quantity sufficient for commercial sowing have failed, due to storm, insects, or other adverse conditions. A good crop of seed was secured from the increase plat of this variety harvested in August, 1920, at East Lansing, Mich. After reserving a portion for insurance against loss of a winter crop, $2\frac{1}{2}$ bushels were planted early in November at Fairhope, Ala., on the east side of

Mobile Bay. This was harvested April 22, thrashed May 3, and some of the seed sown at East Lansing two weeks later. The summer crop in 1920, at East Lansing, gave an increase of about twenty-five times the quantity of seed planted and the winter crop at Fairhope, an increase of about eight times, or a total increase of nearly two hundred times for the two crops. Some of this seed has been sown this season by fiber-flax growers, who will save the seed produced. A seed supply of this improved variety, therefore, seems assured.

In very severe tests in "flax sick" soils (infested with wilt, *Fusarium lini*) at the experiment stations at Fargo and Mandan, N. Dak., the pedigreed strains of fiber flax were found to be very resistant to wilt. They were also less attacked by rust (*Melampsora lini*) than other varieties of flax.

HEMP.

The production and distribution of pedigreed hempseed has been continued. More than 500 pounds grown in the selection plats at Arlington Farm in 1920 were distributed in the spring of 1921 to 37 different growers. There is an increasing demand for this pedigreed seed by the commercial hempseed growers of Kentucky, and since 2 or 3 pounds will plant an acre, producing 10 to 20 bushels of 44 pounds each, it increases rapidly. One bushel sows an acre for fiber production.

The high standard of the varieties that have been developed by many years of selection is being kept up, and two new hybrids, now in the second generation, give promise of superior value. Seeds are not distributed until after the hybrids or other strains have been tested beyond the third generation.

The organized hemp growers of Wisconsin, working in cooperation with the field agent of fiber investigations, have so improved the quality and standardized the grades of hemp fiber produced there that it has found a market even in dull times. The hemp acreage in that State has been kept up, although there has been a reduction in every other hemp-producing area throughout the world.

PLANT-NUTRITION INVESTIGATIONS.

These investigations deal chiefly with the effect of light, and more especially the length of the day, on plant development; the effects of crops on other crops following in the rotation; the functions of the plant food elements in nutrition. Continuing the work on the relation of length of day to plant growth it has been found that not only the processes of flowering and fruiting, but also the formation of tubers and bulbs, falling of the leaves, the condition of dormancy, resistance to cold, development of branches, extent of root growth and other features of growth are subject to control by the prevailing length of day. In addition to the direct application of these results in practical floriculture and horticulture they seem to offer important possibilities in the discovery or the production of new varieties of crop plants by the plant introducer and the plant breeder. These investigations emphasize in a way not previously recognized the importance of knowing the correct season for planting each variety of crop plant to insure highest returns.

The field studies on the effects of crop plants on succeeding crops in the rotation have been continued and somewhat extended. The results show that these crop effects must be taken into account in dealing with the problems of soil productiveness. The action of fertilizers is modified by these crop relationships to such an extent that results with any given cropping systems can not be safely applied to other cropping combinations even when the modification of the system would appear to be unimportant.

SOIL-FERTILITY INVESTIGATIONS.

FERTILIZER REQUIREMENTS OF IMPORTANT SOIL TYPES.

An important phase of the investigations in soil fertility is the fertilizer study on important soil types to determine the plant food requirements of the principal crop grown on the type. The soil types selected for study are those covering large areas in the United States devoted to important crops to which they are particularly adapted. These studies, begun in a small way in 1916, have grown in extent and importance as the result of a steady demand for their extension into new territory comprising large soil regions devoted to specific but important crops. The main crops of the regions, representing millions of dollars of agricultural wealth, are grown and studied with a view to their fertilizer requirements. The crops grown comprise potatoes, cotton, and corn, leading money crops of the country, as well as pecans, peaches, grass, clover, sorghum, sugar beets, celery, lettuce, etc. The results show clearly that the plant food requirements of these crops is different on the different soil types upon which they are grown, some soils responding most to high nitrogen fertilizer and some to high phosphate or high potash fertilizer. The best ratio of plant foods, or proper fertilizer formula, is ascertained and the results are of practical value to the growers in the regions studied, resulting frequently in a saving of thousands of dollars to the growers in the purchasing of properly balanced fertilizers.

POTATO-FERTILIZER STUDIES.

Fertilizer studies on potatoes are carried out in a number of the principal potato sections of the Eastern States where fertilizers are heavily used. The principal locations are Aroostook County, Me.; Long Island, N. Y.; central and southern New Jersey; eastern Pennsylvania; Norfolk and Cape Charles regions of Virginia; and the New Bern section in North Carolina, covering a number of the most important soil series on which potatoes are produced along the Atlantic seaboard, namely, the Caribou and Washburn loams, Sassafras loam and sandy loam, Penn loam, Berks shale loam, Norfolk and Portsmouth fine sandy loam, and related types.

The plan of experimentation includes a great many fertilizer combinations, the constituents, ammonia, phosphate, and potash being combined in various ratios. In each case the best ratio of ammonia, phosphate, and potash in the fertilizer is determined for each region and the results obtained are of great economic value to the grower in solving their fertilizer problems.

There are also included in these experiments a number of the nitrogen sources, embracing the principal inorganic and organic ammoni-

ates, with a view to studying their relative efficiency in the different soil types.

A section of the experiment is devoted to a comparison of potash materials, a study of which is particularly appropriate in connection with the potato crop, since potato growers are heavy users of potash materials. The results show conclusively that a material saving in the fertilizer bill can be made by using somewhat less potash in practically all of these regions than was customary before the war. There is also a study of the quantity of fertilizer per acre to use in each locality for the most profitable returns. On some of the soil types, for instance, a maximum profitable production is obtained with less fertilizer than is commonly used by the growers, while in others the fertilizer application can still be increased with profit.

COTTON-FERTILIZER STUDIES.

Fertilizer studies are in progress in the cotton region of the South Atlantic States, where the fertilizer consumption is undoubtedly the most intensive in the United States, approximating 3,000,000 tons in the States of Georgia, North Carolina, and South Carolina alone. The principal centers for these experiments are at present at New Bern, N. C., Fayetteville, N. C., Florence, S. C., and Bennettsville, S. C., on the Coastal Plains soils, and at Ashboro, N. C., and Athens, Ga., on the Piedmont soils. The principal soil types on which cotton is grown in these regions are selected and comprise the Ruston sandy loam, Portsmouth sandy loam, Norfolk sandy loam and fine sandy loam, Marlboro sandy loam, Georgeville sandy loam, and Cecil clay loam. On these prominent cotton soils fertilizers of various ratios in phosphate, ammonia, and potash are tested out in carefully controlled field tests.

SEED TESTING.

During the year 1920-21 the seed-testing laboratories received and examined 25,797 samples of seeds. Of these, 14,229 came to the Washington, D. C., laboratory, and 11,568 to the five branch seed-testing laboratories maintained in cooperation with State institutions. These samples represent both vegetable and field seeds from farmers, seed dealers, and investigators, to whom reports of analyses were sent showing the presence of weed seeds and worthless material, or germination, or both, as requested. Through this service the work of the seed-testing laboratories is immediately applied to practical agriculture.

ENFORCEMENT OF THE SEED IMPORTATION ACT.

The total importations of forage-plant seeds subject to the seed-importation act were approximately half of that of the previous year. The chief item was red-clover seed, sixteen and one-third million pounds being imported, mostly from France. The next largest items were five and one-half million pounds of crimson clover, four and one-half million pounds of alsike clover, four million pounds of rape, and smaller quantities of English ryegrass, hairy vetch, Canada bluegrass, and alfalfa seed.

Comparatively little seed was prohibited entry during the fiscal year of 1921, as the general quality of the seed offered for import into the United States was higher than during the previous year. A few of the lots which were prohibited entry were of no value for agricultural purposes.

DRY-LAND AGRICULTURE.

Investigational work is under way at 22 field stations in the Great Plains: 9 of the stations are independent stations, controlled and operated by the bureau. These stations are located at Mandan, N. Dak.; Sheridan, Wyo.; Ardmore, S. Dak.; Akron, Colo.; Woodward, Okla.; Dalhart, Tex.; Tucumcari, N. Mex.; Lawton, Okla.; and Big Spring, Tex.

The work at Dickinson, Edgeley, and Hettinger, N. Dak.; Havre and Judith Basin, Mont.; North Platte, Nebr.; Colby, Hays, and Garden City, Kans.; and Archer, Wyo., is conducted cooperatively with the agricultural colleges and State experiment stations of the respective States, and the experiments at Huntley, Mont., Belle-fourche, S. Dak., and Scottsbluff, Nebr., are carried on cooperatively with the Office of Western Irrigation Agriculture.

The results obtained from the experiments conducted at these stations can be summarized as follows:

(1) Systematic experiments dealing with dry-land agriculture have been carried on at these stations for a period of years, giving more reliable information on the subject than has heretofore been available. State experiment-station investigators of this country and Canada recognize this fact and have accepted the results as the most authentic work on the subject.

(2) A better knowledge of the agricultural possibilities of the Great Plains is being gained, and we are thereby enabled to give the farmers of this region reliable information.

DEMONSTRATIONS ON RECLAMATION PROJECTS.

During the year demonstration work has been under way on 14 of the 24 reclamation projects, as follows: Newlands, Nev.; Minidoka, Idaho; Huntley, Mont.; Uncompahgre, Colo.; Umatilla, Oreg.; Shoshone, Wyo.; North Platte, Nebr.-Wyo.; Belle Fourche, S. Dak.; Yuma, Ariz.; Williston, N. Dak.; Lower Yellowstone, Mont.-N. Dak.; Sun River and Milk River, Mont.; and Grand Junction, Colo.

LIVE-STOCK INDUSTRIES.

Dairying.—Of the agricultural industries emphasized, dairying has been encouraged more than any other. The reason for this was due to several factors, one of the chief ones being that the close of the 1920 growing season found the farmers on reclamation projects with a large crop of alfalfa hay on their hands with no market for it. Another one was the rapid decline in wool and meat products, which make the cattle, sheep, and hog industries unprofitable. This left dairying the only industry whose products seemed to have a ready market at a price above the cost of production. Realizing

these conditions the field men directed their efforts to the increasing of the dairy-cow population on their respective projects. The need for more dairy cows was brought to the attention of the farmers through meetings, the press, and personal visits. This propaganda, stimulated by the conditions soon created a live interest in dairying to the extent that those farmers who had feed wanted from 5 to 10 cows. The full benefit of the movement was not realized, as many farmers were without means with which to purchase cows, and the money market had tightened so that it was impossible for them to secure any kind of a loan from their banks. Notwithstanding this fact the movement resulted in bringing to the project a number of carloads of high-grade dairy cattle.

In addition to this work, assistance has been given the farmers in testing and culling their herds, in disease control, in feeding, and in selecting their herd sires. The demonstration work has been influential in the construction of several new silos and barns. The work with irrigated grass pastures, in connection with dairying, has been encouraging, the acreage on some of the projects having been increased 35 per cent.

Swine production.—The hog industry has not recovered as yet from the severe blow it received in 1919 from the high price of feed and labor coupled with high freight rates and a low price for pork. The hog population on most of the projects decreased in 1919-1920 from 25 to 70 per cent. Since that time the price of pork has remained low and it is only within the last few months that the industry has begun to revive. Work in this industry has been confined almost entirely to disease control and pig-club work with the boys and girls. Much interest has been taken in the club work, and through it an opportunity has been given to demonstrate the advantages of good breeding and feeding.

Sheep raising, though not a large industry on the projects, has been quite popular, the aim being to keep a small flock on the farm to clean up the ditch banks and other waste places. Some farmers, however, have entered into it more extensively by developing a pure-bred flock from which they have furnished rams to the range men for their flocks. Two important phases of the industry to project farmers have been the feeding of lambs for market and the wintering of range flocks for sheepmen. This has always been one of the chief outlets for the farmers' surplus alfalfa hay. The high price of feed and labor during the hard winter of 1919-20, together with the heavy losses in both sheep and lambs and the collapse of the wool and mutton market, nearly ruined the industry. During the past year there has been little or no interest in sheep raising. The work done in connection with it has been the organizing of a few wool pools and the giving of information on the care and improvement of farm flocks.

Beef industry.—What has been said with reference to the reverses in the swine and sheep industries is equally true of the beef industry. The principal work with this industry has been disease control, especially blackleg, and the organizing of the small farm herd into units large enough to enable the beef raisers on the projects to take advantage of the summer ranges in the national forest reserves.

Poultry industry.—On three of the projects—the Newlands, Minidoka, and Uncompahgre—some attention has been given to stimu-

lating the poultry industry. Housing, breeding, feeding, and culling have been emphasized. Poultry clubs for boys and girls also have been encouraged.

IRRIGATION.

The assistance rendered farmers on the Umatilla project during the past few years in laying out their irrigation systems has been continued. This work has been appreciated very much, as is evidenced by the results. The border method of irrigation, recommended by this office for the project, is now in use on 25 to 30 per cent of all the land irrigated and on 90 per cent of the new land being brought under cultivation.

In response to urgent requests made by the settlers on the Milk River, Sun River, and Lower Yellowstone projects in Montana and the Williston project in North Dakota for help in the solution of some of their farm irrigation problems, some temporary field demonstration work was inaugurated on these projects in the spring of 1920 and continued throughout the irrigation season. The same work has been carried on again this season on the Sun River and Milk River projects. On account of a lack of funds it was not possible to undertake it again on the other two projects. The services of our field men in this work are very much in demand. Practically their entire time has been spent in planning and laying out farm irrigation systems. The work has been very popular and very much appreciated.

CONGRESSIONAL SEED DISTRIBUTION.

During the fiscal year 1921 there were distributed on Congressional and miscellaneous requests 6,243,604 packages of vegetable seed and 787,401 packages of flower seed, or a total of 7,031,005 packages, each containing five packets of different kinds of seed. There were also distributed 13,541 packages of lawn grass seed and 10,879 packages of imported narcissus and tulip bulbs. The seeds were purchased on competitive bids as heretofore. The bulbs were grown on the United States Bulb-Propagating Garden, Bellingham, Wash. Each lot of seed purchased was thoroughly tested for purity and viability before acceptance by the department, and tests of each lot of seed were conducted on the department's trial grounds to determine trueness to type.

The work of packeting, assembling, and mailing the vegetable and flower seed was done by a private contractor, at a price of \$2.66 a thousand packets, including the furnishing of the packets and envelopes.

NEW AND RARE FIELD-SEED DISTRIBUTION.

A distribution of new and rare field seeds was made throughout the entire United States, having for its object the dissemination of seed of new and rare field crops, seed of improved strains of staple crops, and high-grade seed of crops new to sections where the data of the department indicate such crops to be of considerable promise. Each package contained a sufficient quantity of seed for a satisfactory field trial, and the recipient was urged to use the seed, if feasible, for the production of stocks for future plantings. A report card

and a circular giving full directions for the culture of the crop accompanied each package of seed.

Only seed of new crops, or of improved strains of standard crops, were distributed, as follows: Dakota-grown, Grimm, Kansas-grown and Peruvian alfalfas; Great Northern field beans; white sweet clover; Brabham, Catjang, Early Buff, and Victor varieties of cowpeas; Spur feterita; Bangalia, Chang, Gregory, and Paragon field peas; Carpet grass, Merker grass, Napier grass, Natal grass, orchard grass, and Rhodes grass; Dwarf Blackhull kafir; Kursk and Siberian millets; Dwarf Yellow milo; Dakota Amber, Red Amber, and Sumac sorghums; Biloxi, Black Eyebrow, Barchet, Easy Cook, Haberlandt, Hahto, Ito San, Laredo, Mammoth Yellow, Manchu, Mandarin, Peking, Tokio, Virginia, and Wilson-Five varieties of soy beans; Sudan grass; Bush, Georgia, and Osceola varieties of velvet beans; and Acala, Columbia, Dixie, Durango, Holdon, Lone Star, Meade, and Trice varieties of cotton.

During the year, 110,000 packages of new and rare forage-crop seed and 58,791 packages of cotton seed, or a total of 168,791 packages, were distributed.

One of the most important features of the new and rare seed distribution for the fiscal year 1921 was the distribution of spur feterita, an improved strain of feterita developed by the Texas Experiment Station. This strain has indicated its superiority over common feterita, and it is believed it will be a valuable addition to the forage crops of the southern Plains. There was a wide distribution of seed of carpet grass, which was commercialized in considerable quantities this year for the first time. A special effort was made to encourage the harvesting of carpet grass seed, and by distributing small packets of it, it is believed that its spread will be hastened very materially. The Bush velvet bean was distributed in considerable quantity, and much progress was made in establishing it as a staple crop, especially in citrus and other orchards of the South.

EXPERIMENT STATION FILE
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REPORT OF THE CHIEF OF THE BUREAU OF PUBLIC ROADS.

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF PUBLIC ROADS,
Washington, D. C., October 15, 1921.

SIR: I have the honor to submit herewith the report of the Bureau of Public Roads for the fiscal year ended June 30, 1921.

THOS. H. MACDONALD,
Chief of Bureau.

HON. HENRY C. WALLACE,
Secretary of Agriculture.

INTRODUCTION.

The fiscal year 1921 has been an unusual one from many standpoints. The first part of the year, that is, from July to October, 1920, was marked by railroad congestion, material shortages, high prices, and scarcity of labor. These conditions not only worked to the disadvantage of contractors who had entered bids when prices were lower and working conditions more favorable, but they also tended to reduce the amount of work placed under contract and generally to obstruct the progress of highway construction. About the close of the 1920 working season there was in progress a change in general economic conditions which continued throughout the winter. As a result, when the 1921 working season opened, labor was more plentiful and wages were somewhat lower; the material supply, because of large curtailments in general building enterprises, was adequate, and the car shortage, which had been so large a factor in hampering the preceding year's work, was entirely eliminated. There had appeared, however, instead of the labor, material, and transportation difficulties of the previous year, the money stringency, which has marked the balance of the fiscal year 1921. During this period bank credits have been difficult to secure, bonds have been disposed of with difficulty, and while construction work has gone steadily forward and a large amount of new work has been let, the bid prices have not been reduced below last year's figures as greatly as had been expected.

The improvement in the supply of open-top cars during the latter part of the year was due to the general reduction in business activities rather than to increase in the number of cars; but regardless of the cause, the availability of cars to transport material as needed has contributed helpfully to the prosecution of construction work.

The adverse feature of the transportation situation lies now in the rates charged rather than car service. The heavy increases which went into effect early in the year have increased the costs of going projects, it is estimated, by as much as 10 per cent in some cases; and they have also operated to restrict the territory served by the producers of material and thereby to reduce competition.

The available supply of materials, in so far as it affects highway construction, has been greatly improved, and as the year closes may be said to be satisfactory. What part of this improvement was due to the absence of the building trades from the material market it is difficult to determine. That the falling off in these activities was partly responsible, however, there is no doubt, and it is likely, therefore, that resumption of building will bring about a less favorable situation from the standpoint of highway construction.

The same conditions that have resulted in the elimination of the car shortage and the improvement in the material supply have also brought about an improvement in the labor supply and some reduction in wages. At present there is an adequate supply of labor on all highway construction work, and wages are somewhat lower than a year ago. The principal advantage that has been gained from the present situation is not, however, in the direct reduction in the wages but in the increased efficiency of the men employed and in the reduced turnover. A high turnover always means a low output per man because of the time needed to teach men the operations that are required and to train them to work steadily and effectively as units in a construction organization. Reduced turnover, in combination with the willingness of men generally to work harder than a year ago in return for their wages, has probably been the chief benefit from the improved labor supply.

As mentioned briefly above, the outstanding difficulty which remains at the close of the fiscal year is the money stringency. The difficulty experienced in this respect has been felt most keenly in the States which have been practically dependent upon the sale of bonds for revenues with which to carry on their work. In some cases it has been impossible to sell these securities at the rates authorized by law. Other States, affected less directly, have nevertheless suffered as a result of the difficulty experienced by contractors in getting financial assistance. Such assistance has been and continues to be difficult to obtain. To obtain money contractors have been required to pay higher interest rates and liberal commissions, which necessarily reappear in the prices bid. Another important result of this condition has been to prevent men of limited means and credit who might, in normal times, have secured banking assistance, from obtaining such help.

The net result of these conditions, some favorable and some adverse, has been a slow but steady reduction in the prices bid on highway construction. On close analysis it appears that the greatest reduction has been experienced in the costs which are least effected by transportation conditions. For example, the cost of grading has dropped much more than the cost of surfacing the roads. Grading costs, in fact, as shown by the early fall lettings have dropped practically to the 1914 level, while the costs of the materials which enter into structures and surfaces remain considerably above the prewar figures. Considered altogether, however, prices are much more favorable than they were a year ago. Encouraged by this change for the better, many States have advertised for contract large sections of road for which the plans had been prepared during the period of high prices; and at the end of the year it appears that the season's work generally will show the greatest advance in actual construction thus far recorded.

THE GROWING DEMAND FOR ROADS.

The progress made, however, though highly gratifying when considered in the light of the economic limitations, still falls far short of meeting the demand for improved roads which comes from all classes of our people. Responsible for the demand, in large measure, is the phenomenal development of the motor vehicle, the numbers of which continue to increase each year at a rate which gives no sign of diminishing. Nearly 10,000,000 are now in use, approximately twice the number which were registered when this country entered the World War, and their widespread use by the farmer, the merchant, the manufacturer, and the tourist has created a demand for suitable roads alike by all classes.

The demand of the farmer is for roads from the shipping points and agricultural centers to the surrounding producing areas—farm-to-market roads—which will enable him to market perishable crops with certainty and profit and thereby remove one of the most serious causes of failure which he has had to combat.

The manufacturer and city merchant ask principally for roads which will facilitate the transportation of the raw materials and manufactured commodities which flow to and from the cities.

The tourist and that large section of our urban population whose direct interest in the rural roads is due to the opportunities for pleasurable recreation which they afford, are particularly concerned in the development of a system of smooth, hard-surfaced roads connecting the cities and points of natural interest.

Thus from the several classes the demand is for roads to meet their particular requirements, while all unite in an appreciation of the need for development of a system of roads which shall serve as a complete supplement to the railroads in the event of war.

All these are proper demands, which must be accommodated as rapidly as the resources and means of construction will permit; and fortunately the more important requirements of each group may be met by the improvement of a relatively small part of our mileage of public roads.

HEAVY MOTOR TRUCKS PRESENT PROBLEM.

By all means the most important development in highway traffic from the standpoint of the road builder is the increasing use of the heavier motor trucks. The reduced unit cost of operation which follows from the transportation of commodities in greater bulk tends to promote the development and use of vehicles of the largest capacity which can be utilized to advantage. It is desirable to gain this advantage, if it is actually an advantage, but it is this point which is seriously in doubt. The doubt arises from the fact that the roads which are adequate for traffic of automobiles and light trucks are entirely unable to support the weight of the heavier trucks, and to build roads which will carry the heavy vehicles will greatly increase the costs of construction. Whether the operation of the heavier vehicles shall be restricted to a class of roads especially designed to accommodate them, or whether all roads shall be strengthened to provide for unrestricted use, or whether the third alternative shall be adopted and the operation of the heavier trucks prohibited, will

depend upon the relation which is found to exist between reduced operating cost and increased cost of construction.

The situation presents an economic problem of the first importance, which is not to be hastily solved, but which must nevertheless be met and disposed of. To do so demands a careful weighing of the effects of the several possible solutions with a view to the selection of that one which, in the long run, will serve best to accomplish the one desirable end—the improvement of our means of transportation.

THE IMPORTANCE OF ECONOMIC AND ENGINEERING RESEARCH.

The prime importance of an accurate knowledge of the weight of the vehicles which are to use the roads constructed is well illustrated by the experience of one of the States in which the Bureau of Public Roads made an extensive investigation during the past year. Ten years ago this State set out upon the construction of a system of roads. The roads were designed and built to meet all the reasonable demands of the traffic which could then be foreseen. In the brief time that has elapsed roads have been constructed which penetrate to all parts of the State, some of which, however, have been seriously damaged by heavy motor vehicles the use of which could not have been foreseen when the roads were constructed. Our investigation reveals that in this case the return from the roads in the reduction of the cost of transportation and in the development of the territory they traverse has undoubtedly compensated the loss resulting from their destruction; but it is not by any means certain that the outcome will be so fortunate under other conditions.

For the security of the enormous investment which is now being made by the States and Federal Government it is imperative that this question of the duty which the roads will be called upon to render in the future shall be definitely determined. To afford the assurance which is needed it may be necessary to place limits upon the size of vehicles by suitable legislation; but before this is done it is important that a clearer conception of the relative economy of heavy and light vehicles be gained by careful study.

Less urgent but no less important than the need for economic research is the necessity for careful investigation of the engineering problems of design and construction. The forces imposed upon the roads by modern traffic greatly exceed those of a decade ago. To withstand them it has been necessary to alter the design of road surfaces and foundations. In the absence of definite knowledge of the effect of the traffic and the qualities of the new types of surface, it has been necessary to resort to empirical processes. These must give way as rapidly as possible before more rational methods developed by scientific study.

A brief description of the extensive program of research which has been undertaken by the bureau is given elsewhere in this report. In addition to the work which has been undertaken in our own laboratories and by our own forces in the field, we are also cooperating with a number of the State highway departments and universities in other lines of investigation. It is not too much to say that these investigations have already yielded more precise, scientific knowledge of the forces applied to our highways than engineers have ever before possessed, yet compared to the enormous expenditures for the construction and maintenance of highways their cost is insignificant indeed.

EXPANSION IN FEDERAL-AID WORK FOLLOWING INCREASE IN FUNDS AVAILABLE.

The original Federal-aid act appropriated \$5,000,000 for the fiscal year 1917. This sum did not become available until after the beginning of the fiscal year, and as the act prescribed numerous preliminary requirements, which entailed a great deal of preparatory work on the part of the bureau and the States, it was possible to complete agreements for very few projects during that year. Indeed the projects agreed upon involved only about a quarter of a million dollars of Federal money and approximately an equal amount from State funds. As the sum total of all highway work in progress at the time involved nearly \$300,000,000 it will be observed that the Federal contribution was relatively insignificant. Since this small beginning, however, the Federal funds available have increased annually, and the work undertaken has increased in proportion. By the close of the fiscal year 1918, the funds made available in 1917 had been placed under agreement. At the end of the fiscal year 1919, the amount under agreement exceeded the funds available up to the beginning of the year; and a similar condition has existed at the close of each succeeding fiscal year. The agreements executed this year bring the total amount of Federal money under agreement up to nearly \$200,000,000, an amount greater by \$30,000,000 than the total funds available up to the beginning of the year. At the close of the year the total estimated cost of the Federal-aid work under construction amounted to over \$321,000,000, about 50 per cent of the funds available at the time from all sources.

The rapid increase in the funds available, beginning in 1918 and continuing with greater acceleration in the succeeding years, has naturally resulted in proportionate increase in the work falling upon the Bureau of Public Roads. To indicate the volume of business handled in 1920, the report for that year stated that as many as 400 vouchers were passed in a single month. During the past year this rate has been doubled.

To handle the greater volume of work it has been necessary to make certain changes in the organization, designed principally to reduce the amount of work centering in the Washington office. A fuller measure of authority has been granted to the district engineers, who are now permitted to decide upon proposed changes in the plans of projects under construction without authority from the headquarters office even when such changes involve increase in the amount of Federal funds required. This change was made necessary to avoid the delay incident to the exchange of correspondence formerly required. For the same reason it has been found desirable to establish a regional office at San Francisco with a deputy chief engineer in charge to handle the work of the 6 western districts in which are included the 11 Rocky Mountain and Pacific States. Through this office a large number of routine matters are disposed of without direct reference to Washington. In the Washington office the engineering branch has been divided into a division of design and a division of construction; the former having for its duties the handling of all applications and preliminary matters to the execution of an agreement, including the plans, specifications, and estimates, and the division of construction being charged with the general supervi-

sion of construction work in progress, the checking of construction estimates as they are presented by the States in vouchers claiming Federal-aid payments, and the supervision of maintenance. The regional office in San Francisco is correspondingly divided into subdivisions of design and construction which correlate with those in Washington. In addition a division of control has been created for the purpose of more rapidly and systematically collecting data relative to Federal-aid and other highway statistics and for maintaining the necessary control accounts, showing the status of Federal aid applied for, allotted, and paid to the several States. At the end of the fiscal year this organization was tentative in nature and had been operating less than three months.

As Federal-aid work has grown in proportions there has been an inevitable expansion of the bureau, but the increase in the personnel has been very much under the increase in work. In the early administration it was inevitable that the administrative organization would be relatively large. This is primarily accounted for by the fact that from the very first, when the actual accomplishments were practically nil, it was nevertheless imperative that a complete field organization be maintained. This organization was much smaller than at present, but it had to be sufficiently large to reach all States and perform all of the functions it now performs with a program of actual construction the cost of which is over \$300,000,000. Many of the States had to perfect or create organizations for handling Federal aid. In practically all States some adjustment of State and local finances had to be made to meet the State's share of the cost of construction, and these preliminary operations all had the effect of retarding actual construction work without, however, dispensing with the need of a complete field organization.

With the changes indicated above, however, the organization as originally created has stood the test of a very large increase in the work and has handled the increasing business from year to year without difficulty. The amount of Federal aid actually placed under agreement in the fiscal year 1919 was approximately \$52,000 per employee, and the construction program amounted to \$327,800 for each field engineer in the organization. During the past year the Federal aid under agreement had risen to over \$185,000 per employee, and the construction program reached \$1,103,752 per field engineer.

FEDERAL-AID PROGRESS.

General progress during the past year has been closer to normal and to the expectations entertained for the program than in any previous year.

Owing to the fact that it was the fifth and last year for which appropriations were provided in the original act and its amendments, and to the further fact that the appropriations for the fiscal years 1920 and 1921 varied by only \$5,000,000, the number of new projects submitted did not increase.

The fact that a new apportionment of funds was not made in January, 1921, made it impossible for the States to maintain an unbroken continuity of policy and administration in respect to Federal-aid work, and this condition has resulted in an unprecedented number of withdrawals, cancellations, and modifications of existing

projects as the States have endeavored to adjust their programs to a reduced rate of expenditure. This condition has emphasized the fact that in so large and important a national policy as Federal aid implies, the action of the Federal Government should as nearly as possible be uniform, consistent, and prompt. The probable cost of administering Federal aid in the several States will no doubt be appreciably increased, owing to the fact that the States do not yet know whether Federal aid will be continued, under what conditions it will be continued, or what appropriation is likely to be made, so that it is practically impossible for them to make any definite plans with respect to the administration or financing of future work or to conduct the necessary studies preparatory to filing applications for additional aid.

The number of project agreements executed during the year showed a considerable increase. The Federal aid involved approaches closely the limit set by the greatest annual appropriation. This rate may be expected to drop off during the ensuing year on account of the failure to appropriate further funds this year.

The greatest advance has been made in the number of projects under construction and completed. At the close of the fiscal year 1920 there were 292 projects completed, totaling 1,677 miles and involving \$8,920,353 as the Federal share of their estimated total cost of \$20,878,484. In addition to these there were 1,835 projects under construction. These projects, aggregating 14,940 miles in length, were reported as 30 per cent completed. Their total estimated cost was \$241,977,217, and the Federal aid allotted to them was \$103,925,094.

The work of the past year has added almost a thousand completed projects, and the projects under construction, exceeding by 300 the number in progress a year ago, were reported as 50 per cent complete. The mileage of completed projects at the end of the year was 7,469; their total estimated cost was \$112,447,654, of which the Federal share was \$49,981,635. The projects under construction totaled 17,978 miles in length, and it is estimated that they will cost \$321,560,093, of which \$135,309,516 will be paid as Federal aid. The actual Treasury payments for completed work amounted to \$78,695,430.

The tabular statement which follows shows the progress during each of the five years since the passage of the Federal-aid act.

Summary of project statements approved, project agreements executed, and projects completed by fiscal years.

Year.	Project statements approved.			Project agreements executed.		
	Number of projects.	Estimated cost.	Federal aid requested.	Number of projects.	Estimated cost.	Federal aid requested.
Reported for fiscal year—						
1917.....	23	\$1,845,434	\$846,152	6	\$547,062	\$221,717
1918.....	557	41,053,201	15,478,090	218	14,239,939	5,655,458
1919.....	736	91,495,788	38,664,357	454	41,631,732	18,015,442
1920.....	1,670	252,530,183	109,830,396	1,288	197,571,626	85,906,556
Now reported for fiscal year						
1921.....	1,320	202,764,414	84,114,951	1,653	213,905,671	89,936,506

Summary of project statements approved, project agreements executed, and projects completed by fiscal year—Continued.

Year.	Projects completed.			Federal-aid payments.
	Number of projects.	Estimated cost.	Federal aid allotted.	
Reported for fiscal year—				
1917.....	1	\$53,939	\$24,245	.....
1918.....	6	445,127	198,013	\$425,446
1919.....	53	2,668,739	1,010,091	2,702,248
1920.....	232	17,710,689	7,688,005	19,593,431
Now reported for fiscal year 1921.....	973	91,569,170	41,061,282	55,974,305

NOTE.—The figures here given for fiscal years 1917, 1918, 1919, and 1920 are from annual reports for those years. As projects are modified from time to time, a project occasionally withdrawn, etc., sums drawn from the figures here given will not agree with the figures shown in the larger tables, which, in all cases, have been corrected to June 30, 1921.

LOCATION OF FEDERAL-AID ROADS.

One of the earliest policies formulated by the Secretary of Agriculture in connection with the operations under the Federal-aid act was that requiring of the States a general scheme of the road improvement contemplated by each State under the cooperative plan provided by the act. The policy appears in the Rules and Regulations, issued September 1, 1916, less than two months after the passage of the original law.

This requirement, the wisdom of which has never been questioned, placed upon each of the States a serious duty which, because of the conditions existing, was of necessity met with widely varying degrees of success. In some of the States there were already in progress definite highway programs under existing State organizations. In these States, systems had already been defined which met the requirements of the time. There were, however, a number of States which had no State highway department, where no attempt had ever been made to determine the principal or secondary lines of traffic, where no surveys of materials had ever been made, no State highway maps were in existence, and where even mileage data could not be secured with sufficient accuracy to present more than very general figures built up on the basis of county reports. In such States the highway departments, newly created to meet the requirements of the Federal act, were at a serious disadvantage in presenting any definite program, and in some cases they were forced to resort to the use of highway maps provided by nonofficial civic organizations. It is not surprising, therefore, that their systems were ill-considered and that they contained numerous faults, not the least of which was the total disregard of proper connections at their boundaries with the programs submitted by adjoining States.

Some of the programs submitted consisted of a comparatively restricted mileage, partly determined in connection with a general plan of improvement already under way in the State and limited by State bond issues. In other cases where the known resources of the States were much less, unduly large and comprehensive programs were furnished. With such a variety of proposals submitted by the States, there was imposed upon the bureau the burdensome duty of scrupu-

tinizing each project as submitted, distinguishing the unimportant from the important, and approving only such projects as would probably conform to the requirements of well-considered State systems.

The present policy is to assent to no expansion of the existing State systems, to encourage a reduction of the systems as revisions are made, and as individual projects are considered to assure that they lie on routes which are sufficiently important to warrant complete improvement as construction work is continued over a period of years.

In order to develop clearly the relation of the several State systems, a set of base maps on a scale of 1 to 500,000 is being prepared for the bureau by the Geological Survey. On these maps it is proposed to lay out the building programs of the several States and the systems of roads on which Federal aid is to be applied. Whatever lack of connection there may be at the State lines will be developed clearly by the maps, and special efforts will then be directed to the correction of such conditions. At the end of the fiscal year this set of maps was approximately 70 per cent complete.

Owing to the conditions under which the State programs were prepared, it was inevitable that there would be cases in which a departure from the original system would be advisable. A careful analysis of the projects approved, however, shows that the average departure for the country as a whole has been only 2.6 per cent.

CHARACTER OF FEDERAL-AID ROADS.

In the approval of Federal-aid projects every modern type of rural road has been recognized as having relative merit. In so large a program of construction distributed throughout a territory like that of the United States no other attitude could be assumed. Not only the technical requirements but the logic of highway economics insisted upon such an attitude. Roads have been constructed over mountain, plain, and desert, on the alluvial soils of the Mississippi Delta, the sand deposits of the Coastal Plain, and the fertile soils of the Ohio and Mohawk Valleys, in such States as New Mexico and Arizona where the local and through traffic is light, as well as in the populous States of the Atlantic seaboard where the traffic is exceptionally heavy. Obviously, the standards of approval could not be the same under such a variety of conditions, and the purpose of the bureau has been in all cases to be guided by the best engineering judgment in determining the type or types of construction adequate for each particular project. For both financial and technical reasons, the bureau has recognized two phases of construction, the first including the building of an adequate grade with all necessary drainage structures and with grades and curvature satisfactory for any anticipated future use of the highway. These are the most permanent features of the highway. The second phase involves the placing of adequate surfacing when traffic demands warrant the additional cost. Where only a graded road is constructed the agreement entered into by the State highway department and the Secretary of Agriculture pledges the good faith of the State to construct an adequate surface when the development of traffic and the increasing cost of maintenance indicate the need.

The tabulation of completed projects shows that in the aggregate about one-third of the total expenditure has gone into the preliminary work of grading and drainage; the balance represents the cost of surfacing. Almost half of the total expenditure has been made for surfaces of the highest types, such as brick, concrete, and bituminous concrete, while the expenditure for the less durable surfaces has been only about one-fifth of the total.

ADEQUATE PROVISION FOR MAINTENANCE ESSENTIAL.

Under the original Federal-aid act the duty of maintaining completed projects was placed upon the States or their civil subdivisions, according to the laws of the several States. The alternative here provided for has always been considered a weakness in the original law because of the probable difficulties involved, should occasion arise, in securing prompt and effective action by counties, improvement districts, townships, or road precincts in those States where the duty of maintaining the roads lay with such political units. During the early years of Federal-aid administration this matter was not of great importance because of the small number and correspondingly small mileage of completed projects.

Two years ago, on June 30, 1919, there were only 38 projects completed, or less than 1 in each State. On June 30, 1920, 292 projects had been completed, or about 6 in each State. During the past fiscal year, however, the number of completed projects has increased at a greatly accelerated rate, and on June 30, 1921, there were 1,265 completed projects, representing an investment of \$112,447,654, involving Federal aid in the amount of \$49,981,635, and totaling 7,469 miles. Approximately two-thirds of these projects had been completed subsequent to December 31, 1920. During the present year, therefore, it became apparent that the question of maintenance, which had not been of pressing importance heretofore, could no longer be adequately handled unless the responsibility for such work were more definitely fixed than in the existing law.

A number of cases of unsatisfactory maintenance developed in States where the State highway department did not have direct authority to maintain, and the bureau found the situation exceedingly difficult to handle without resorting to drastic action in cases where, strictly speaking, the State was without practical remedy. In a number of the States with long-established highway departments the maintenance system is so well organized as almost automatically to produce satisfactory results. The difficulties have been encountered in States in which the highway departments have been more recently established, and where separate funds, not under the jurisdiction of the highway department, must be depended upon to finance all maintenance work. In such States the difficulty of securing proper attention to road repair throughout the year, but more especially at times when it is imperatively needed, can not be satisfactorily met under the present law. In several instances persuasion and tact were rewarded by sufficiently prompt action on the part of the local authorities to make application of the formal penalty provided for in the act unnecessary, but in five instances it became necessary to place the State on definite notice that projects were in need of repair and that unless they should be placed in a satisfactory

condition within four months no further projects would be approved by the Secretary of Agriculture. In all of these cases the county rather than the State had jurisdiction over the highways involved.

It is reasonable to suppose that with the number of completed projects rapidly increasing there will hereafter be an increasing number of cases of unsatisfactory maintenance. If the standard of maintenance could everywhere be brought up to a level equal to that prevailing in those States which have the best maintenance organizations, there would be little difficulty, but there is no assurance that such a desirable condition will obtain within a reasonable time, unless some adequate requirement is set up by Federal legislation.

To this end it is recommended that the maintenance requirements of the present act would be a proper subject for amendment along lines which will place the responsibility for maintenance definitely on the States, that will require the States to furnish funds for such maintenance and exercise authority over their expenditure, at least to the same degree as is now required for construction.

The time allowed by the present law within which the States must attend to the maintenance of projects in need of repair is unnecessarily long. The rapidity with which a poorly maintained surface deteriorates under modern traffic is such that the present period of four months may add greatly to the cost of maintenance. Reduction in the time allowed would not only decrease the cost but would insure a longer life for the roads and more continuous service. Provision should also be made for the use of Federal funds under the supervision of the Secretary of Agriculture in case a State is dilatory in giving proper attention after notice, charging the cost of the work against the apportionment to the State until it is refunded by the State. If it be also provided that no further projects shall be approved in the State until such costs are refunded, the tendency will be to avoid the necessity for Federal intervention.

Project statements approved, by States, 1921.

State.	Number of projects.		Total estimated cost.		Federal aid requested.		Mileage.		
	To June 30, 1920.	Fiscal year 1921.	To June 30, 1920.	Fiscal year 1921.	To June 30, 1920.	Fiscal year 1921.	To June 30, 1920.	Fiscal year 1921.	
Alabama.....	72	102	\$3,014,220	\$4,854,018	\$7,898,238	\$5,366,311	461	385	
Arizona.....	24	50	1,485,313	3,990,480	\$8,475,793	1,386,268	352	102	
Arkansas.....	73	97	9,292,846	5,715,567	13,007,413	2,445,369	551	352	
California.....	18	72	12,797,234	3,815,216	16,612,450	6,092,775	584	119	
Colorado.....	58	110	3,285,063	3,963,630	7,248,693	1,609,048	354	147	
Connecticut.....	4	3	1,634,840	1,685,861	3,320,701	540,676	1,330,906	18	
Delaware.....	6	7	1,626,350	2,785,107	1,901,457	294,914	447,655	0	
Florida.....	24	6	7,733,345	3,711,218	6,445,563	1,310,300	1,768,895	34	
Georgia.....	148	59	10,935,756	5,912,699	16,848,455	4,785,974	2,621,605	219	
Idaho.....	34	13	2,521,255	2,369,715	7,639,970	2,521,984	3,360,389	1,033	
Illinois.....	12	11	16,779,739	9,347,588	26,127,327	8,131,632	3,820,178	122	
Indiana.....	21	22	14,843,997	1,148,513	13,635,464	6,986,786	1,315,991	517	
Iowa.....	104	11	16,833,174	4,021,474	20,874,618	7,662,706	3,766,633	1,720	
Kansas.....	54	36	22,438,963	4,191,743	26,610,706	5,594,393	1,423,759	1,018,152	
Kentucky.....	28	22	50	3,601,708	4,968,696	5,753,401	2,388,729	616	
Louisiana.....	46	8	5,576,105	2,683,187	8,264,292	2,648,468	1,087,167	258	
Maine.....	30	2	5,563,941	838,036	5,401,977	2,265,055	363,915	104	
Maryland.....	38	32	8,811,087	1,388,140	5,209,727	1,829,841	551,102	153	
Massachusetts.....	37	32	6,334,626	3,328,493	7,663,119	1,998,403	1,333,144	1,874	
Michigan.....	41	26	8,359,972	7,421,563	15,781,535	3,954,957	2,950,108	555	
Minnesota.....	163	34	17,146,872	3,808,263	20,955,077	7,693,928	121,455	400	
Mississippi.....	50	13	4,208,019	4,293,493	8,501,512	8,485,356	7,815,383	1,970	
Missouri.....	104	79	12,143,454	8,058,968	20,202,422	6,008,853	3,713,223	504	
Montana.....	89	48	5,313,620	5,822,619	11,166,239	2,613,926	1,700,375	397	
Nebraska.....	131	28	9,443,772	2,598,591	12,012,363	4,628,553	1,238,209	860	
Nevada.....	30	12	2,448,343	2,589,881	5,038,774	1,263,619	1,277,695	3,098	
New Hampshire.....	112	19	1,848,178	1,848,178	2,351,744	922,589	1,443,596	279	
New Jersey.....	25	2	8,333,666	5,065,96	10,241,494	2,950,423	1,435,997	137	
New Mexico.....	44	24	3,697,900	2,862,570	6,560,479	1,848,954	3,265,298	1,6	
New York.....	146	81	12,981,209	17,805,370	30,786,579	6,262,354	7,187,716	3,753	
North Carolina.....	118	2	13,100,379	1,02,620	13,037,871	1,06,491	4,116,400	1,255	
North Dakota.....	103	36	4,163,192	4,257,134	8,420,326	2,018,521	2,134,300	246	
Ohio.....	125	55	21,690,479	7,900,280	29,199,759	6,732,565	4,428,305	1,731	
Oklahoma.....	28	50	6,109,762	9,384,356	15,491,118	2,900,647	3,437,590	523	
Oregon.....	39	6	45	6,221,014	2,788,122	9,109,166	1,323,407	4,322,178	574
Pennsylvania.....	82	31	113	25,055,514	5,139,417	30,744,971	1,61,490	1,301,779	34
Rhode Island.....	10	2	1,137,352	416,627	1,553,297	453,489	183,923	325	
South Carolina.....	54	34	88	4,707,060	2,900,442	7,607,502	1,539,892	865,057	1,445
South Dakota.....	55	25	80	8,819,147	3,271,397	8,123,544	2,402,766	1,616,793	1,005
Tennessee.....	28	11	39	6,024,919	5,942,104	11,967,033	2,996,389	5,971,000	1,446
Texas.....	151	257	21,092,019	26,518,467	41,640,486	1,3,3,9,604	7,741,715	3,213	

Utah.....	19	9	28	6,239,284	1—63,223	6,176,061	3,038,862	1—33,171	3,005,688	579	1—164	415
Vermont.....	16	10	26	950,650	904,338	1,863,988	479,825	451,674	931,409	47	20	67
Virginia.....	63	53	116	4,712,086	6,329,476	11,242,162	2,352,062	3,119,688	5,451,730	331	314	675
Washington.....	65	14	79	7,335,970	1,182,547	8,518,517	3,461,566	438,119	3,902,685	353	11	364
West Virginia.....	93	10	103	5,207,437	1,102,856	6,310,293	2,077,886	787,686	2,865,272	325	1—17	308
Wisconsin.....	147	91	238	7,551,573	7,312,190	14,863,763	2,579,493	2,865,013	3,385,506	630	406	1,036
Wyoming.....	66	24	90	4,412,685	2,005,353	6,508,638	2,193,003	940,462	3,139,465	638	57	695
Total.....	2,985	1,320	4,305	384,556,818	202,764,414	587,321,232	163,841,505	84,114,951	247,956,456	29,321	6,084	35,402

¹ Reductions from last year's totals due to modifications, withdrawals, and cancellations of projects.

Project agreements executed, by States, 1921.

State.	Number of projects.	Total estimated cost.		Federal aid requested.		Mileage.			
		To June 30, 1920.	Fiscal year 1921.	To June 30, 1920.	Fiscal year 1921.	To June 30, 1920.	Fiscal year 1921.		
Alabama.....	62	\$3,671,033	\$4,314,833	\$7,985,866	\$2,150,684	\$3,932,636	685		
Arkansas.....	21	39	3,739,022	2,213,312	1,739,318	2,841,909	319		
California.....	45	35	5,346,922	4,915,209	6,153,334	2,132,976	152		
Colorado.....	33	56	5,875,172	5,255,485	2,921,392	2,692,949	921		
Connecticut.....	45	55	100	2,947,452	3,361,125	1,450,904	5,524,341	517	
Delaware.....	7	0	2,554,165	347,436	2,901,601	1,731,781	210	210	
Florida.....	16	4	1,071,585	1,137,070	1,916,139	1,024,288	406	406	
Georgia.....	78	101	3,173,165	4,244,750	4,767,917	535,755	447,655	34	
Idaho.....	10	31	2,017,604	7,817,912	5,341,552	3,466,748	2,012,672	145	
Illinois.....	60	210	18,249,179	7,035,463	25,289,642	8,987,673	3,127,276	1,050	
Indiana.....	19	18	4,690,037	5,114,263	9,804,300	2,260,370	2,576,425	732	
Iowa.....	43	54	11,049,163	8,370,331	14,191,494	4,675,842	4,780,359	284	
Kansas.....	43	32	12,949,977	10,124,962	23,074,939	3,918,010	2,352,712	1,350	
Louisiana.....	22	18	3,586,127	3,651,560	7,137,577	6,689,657	1,747,519	637	
Maine.....	30	16	2,329,293	2,876,938	6,106,251	1,555,692	1,331,079	162	
Maryland.....	12	22	1,196,224	1,743,479	3,939,703	1,020,828	2,880,862	541	
Massachusetts.....	43	18	3,494,069	1,220,787	4,714,856	1,632,380	1,907,622	206	
Michigan.....	34	24	58	3,389,084	2,701,252	6,100,336	1,600,471	2,144,440	517
Minnesota.....	35	22	5,965,854	5,135,260	11,120,884	2,908,165	2,633,629	162	
Mississippi.....	75	79	154	7,662,436	9,255,343	16,917,779	3,218,728	5,301,794	1,682
Missouri.....	34	15	3,185,936	3,740,305	6,927,241	3,446,436	6,665,164	540	
Montana.....	44	51	95	1,089,847	6,343,420	13,433,276	3,049,934	3,563,085	118
Nebraska.....	45	48	3,244,273	4,422,055	7,666,328	3,049,093	3,002,365	371	
Nevada.....	66	36	102	5,812,070	2,449,113	8,809,676	1,632,091	3,611,059	674
New Hampshire.....	23	19	42	2,271,771	4,720,420	8,410,524	2,265,367	1,214,440	1,482
New Jersey.....	82	41	123	3,537,839	669,189	1,133,524	1,191,220	1,191,220	380
New Mexico.....	18	9	27	3,537,158	7,041,336	10,241,494	691,602	2,305,276	131
New York.....	24	33	57	2,806,342	2,849,153	5,655,465	1,403,171	1,422,752	102
North Carolina.....	64	48	94	9,997,068	9,986,675	19,987,743	4,450,210	2,825,293	545
North Dakota.....	42	33	112	5,923,846	6,313,564	12,237,410	2,608,069	8,000,030	803
Ohio.....	49	87	543,275	3,160,559	5,703,834	1,271,637	1,564,617	416	
Oklahoma.....	63	49	15,019,497	6,694,745	21,714,242	4,922,583	2,195,408	952	
Oregon.....	16	27	43	3,688,257	6,257,633	9,958,890	1,799,300	2,575,666	584
Pennsylvania.....	28	16	44	8,806,342	8,806,566	12,702,492	4,429,071	4,785,658	143
Rhode Island.....	79	29	108	18,079,952	9,634,316	28,342,268	7,994,833	2,792,479	172
South Carolina.....	33	39	72	8,233,024	3,791,890	12,553,973	2,008,055	3,622,377	406
South Dakota.....	33	39	52	3,310,131	3,399,174	5,003,024	1,885,677	1,822,650	224
Tennessee.....	23	7	81	13,539,491	13,901,065	13,901,065	3,014,326	3,014,326	1,323
Texas.....	108	81	189	27,471,656	28,282,656	31,436,817	2,683,406	2,683,406	2,224

Reduction due to payment of final voucher.

Summary of completed Federal-aid projects, arranged by States, June 30, 1921.

States.	Number of projects.	Mileage.	Federal aid paid.	Total cost.	Total expenditures (average per mile).			
					Surface.	Grading.	Structures.	Total.
Alabama.....	37	235.0	\$878,981.74	\$1,799,267.35	\$3,660	\$2,400	\$1,590	\$7,650
Arizona.....	7	24.0	302,909.86	661,227.74	15,550	6,620	5,380	27,550
Arkansas.....	11	48.9	141,477.56	367,878.97	5,710	1,555	225	7,520
California.....	11	77.5	595,269.37	1,309,832.56	10,000	5,340	1,560	16,900
Colorado.....	25	63.3	496,040.30	1,033,793.03	8,495	2,860	4,965	16,320
Connecticut.....	1	5.3	53,000.00	125,660.79	21,380	1,884	436	23,700
Delaware.....	3	10.6	117,254.30	844,822.53	56,390	16,720	6,580	79,690
Florida.....	1	10.4	16,938.10	33,951.88	1,496	1,126	642	3,264
Georgia.....	29	107.1	800,083.19	1,662,771.14	5,315	3,075	7,130	15,520
Idaho.....	6	78.9	325,636.53	715,612.81	1,040	5,910	2,130	9,080
Illinois.....	12	40.6	577,801.56	1,159,482.65	23,340	3,455	1,745	28,540
Indiana.....	5	9.7	175,343.22	360,694.65	30,350	3,710	3,120	37,180
Iowa.....	3	24.0	114,334.63	362,899.82	10,260	4,770	90	15,120
Kansas.....	6	9.5	137,211.50	407,728.86	35,960	4,580	2,330	42,870
Kentucky.....	6	20.7	289,249.60	639,775.64	25,270	3,010	2,620	30,900
Louisiana.....	14	112.1	429,235.24	1,007,920.11	6,708	1,302	980	8,990
Maine.....	1	15.6	165,467.35	330,991.59	14,010	5,280	1,910	21,200
Maryland.....	34	92.2	1,186,978.08	2,446,193.11	22,430	2,872	1,218	26,520
Massachusetts.....	11	28.3	340,720.71	748,236.40	20,600	4,400	1,425	26,425
Michigan.....	16	53.3	474,497.14	1,037,249.54	13,970	3,672	1,818	19,460
Minnesota.....	42	549.5	1,423,450.22	3,822,347.28	4,490	1,927	543	6,960
Mississippi.....	13	99.5	341,436.70	704,675.43	3,435	2,360	1,287	7,082
Missouri.....	6	15.8	78,977.86	234,756.83	13,320	1,033	504	14,857
Montana.....	2	2.0	33,020.65	67,069.57	4,986	890	27,659	33,535
Nebraska.....	3	10.6	85,236.10	268,902.96	21,120	4,058	1,179	25,357
Nevada.....	5	32.6	100,365.09	234,551.75	2,580	3,285	1,318	7,183
New Hampshire.....	71	84.9	620,289.02	1,294,848.75	10,960	2,610	1,680	15,250
New Jersey.....	11	37.3	627,984.63	1,503,482.20	31,080	3,750	5,480	40,310
New Mexico.....	11	98.1	504,596.90	1,012,843.17	6,290	2,190	1,840	10,320
New York.....	4	10.3	133,673.37	267,595.68	20,255	4,055	1,650	25,960
North Carolina.....	27	146.2	683,801.59	1,736,875.31	7,405	2,890	1,585	11,880
North Dakota.....	9	122.1	146,176.58	302,621.58	207	1,368	910	2,485
Ohio.....	27	129.7	1,260,543.85	3,594,627.62	24,410	2,150	1,150	27,710
Oklahoma.....	4	7.2	102,374.49	211,932.50	26,050	1,213	2,164	29,427
Oregon.....	18	137.5	931,855.72	1,957,148.51	9,360	3,890	996	14,240
Pennsylvania.....	26	113.7	1,910,387.00	4,169,245.26	26,800	6,475	3,375	36,650
Rhode Island.....	5	10.3	153,085.39	310,571.40	22,955	5,950	1,220	30,125
South Carolina.....	20	79.6	423,021.03	901,773.83	7,255	2,480	1,590	11,325
South Dakota.....								
Tennessee.....								
Texas.....	32	317.5	759,266.70	1,828,140.44	3,365	1,333	1,058	5,756
Utah.....	1		8,250.84	16,501.68				
Vermont.....	6	8.0	78,470.95	160,594.67	13,840	4,900	1,334	20,074
Virginia.....	16	65.9	342,346.45	701,526.14	6,080	3,120	1,440	10,640
Washington.....	56	263.4	2,659,355.58	5,639,296.75	13,660	5,510	2,225	21,395
West Virginia.....	17	22.8	251,151.72	550,686.10	20,420	2,510	1,220	24,150
Wisconsin.....	55	202.2	770,022.43	2,380,703.14	7,740	2,752	1,208	11,700
Wyoming.....	20	169.2	447,038.94	930,699.46	2,208	2,024	1,268	5,500
Total.....	746	3,802.9	22,502,609.78	51,860,009.18	9,040	2,938	1,657	13,635

Summary of completed Federal-aid projects, arranged by States, June 30, 1921—Contd.

States.	Cost by items. ¹											
	Surfacing.								Grading.		Structures.	
	Class 1.		Class 2.		Class 3.							
	Amount.	Per cent.	Amount.	Per cent.	Amount.	Per cent.	Amount.	Per cent.	Amount.	Per cent.	Amount.	Per cent.
Alabama.....	\$488,861.08	27			\$370,996.40	21	\$566,968.45	31	\$372,441.42	21		
Arizona.....	20,868.05	3			351,705.81	53	159,427.36	24	129,226.52	20		
Arkansas.....	150,196.02	43	822,365.71	6	97,765.62	27	77,558.15	21	10,993.47	3		
California.....					774,872.55	59	413,908.56	32	121,051.45	9		
Colorado.....	8,992.70	1			529,129.53	51	181,305.53	17	314,365.27	31		
Connecticut.....					113,410.89	90	9,999.35	8	2,250.55	2		
Delaware.....					597,847.12	71	177,280.62	21	69,694.79	8		
Florida.....	15,556.64	46					11,722.18	35	6,673.06	19		
Georgia.....	150,302.73	9	298,098.97	18	120,825.49	7	330,653.01	20	762,885.94	46		
Idaho.....	33,780.32	5			47,041.08	7	466,704.48	65	168,083.93	23		
Illinois.....					948,002.26	82	140,396.38	12	71,084.01	6		
Indiana.....					294,491.90	82	35,984.82	10	30,217.93	8		
Iowa.....					246,170.92	62	114,581.91	31	2,146.99	1		
Kansas.....					341,929.84	84	48,603.15	11	22,195.57	5		
Kentucky.....			190,608.11	30	332,304.93	52	62,383.67	10	54,278.93	8		
Louisiana.....	619,303.41	61			133,213.10	13	145,975.32	15	109,428.28	11		
Maine.....			218,795.89	66			82,397.85	25	29,797.85	9		
Maryland.....	18,973.00	1	99,916.84	4	1,950,192.98	79	294,945.41	11	112,164.88	5		
Massachusetts.....			361,822.83	49	220,855.77	29	124,727.03	17	40,830.77	5		
Michigan.....	261,761.09	25	26,149.32	3	456,543.13	44	195,883.86	19	96,912.14	9		
Minnesota.....	1,911,144.39	50			554,651.11	14	11,039,202.27	28	297,349.51	8		
Mississippi.....	254,120.95	36			87,672.47	13	234,868.20	33	128,013.81	18		
Missouri.....	6,833.28	3	31,923.88	14	171,711.20	73	15,315.97	7	7,972.50	3		
Montana.....	9,971.80	15					1,779.20	3	55,318.57	82		
Nebraska.....					233,952.33	83	43,036.03	16	1,914.60	1		
Nevada.....	47,291.06	20			36,976.55	16	107,287.68	46	42,995.43	18		
New Hampshire.....	375,373.00	29	212,142.89	16	343,394.93	27	221,210.17	17	142,727.76	11		
New Jersey.....					1,159,129.17	77	139,899.92	9	204,453.11	14		
New Mexico.....	275,393.31	27	81,776.21	8	260,616.67	26	214,560.22	21	180,493.76	18		
New York.....	174,702.33	10	140,678.63	52	68,139.86	26	41,782.89	16	16,994.30	6		
North Carolina.....	25,311.21	8			908,350.02	52	422,304.54	25	231,518.42	13		
North Dakota.....							167,190.05	56	110,120.22	36		
Ohio.....	979,255.88	27	2,187,213.00	61	278,877.04	8	149,281.70	4				
Oklahoma.....					187,609.57	89	5,730.50	4	15,592.43	7		
Oregon.....	373,263.40	20	23,490.19	1	859,225.73	45	535,482.56	27	135,686.63	7		
Pennsylvania.....					3,049,850.39	73	736,222.80	18	383,172.07	9		
Rhode Island.....			181,195.43	58	55,576.61	18	61,286.02	20	12,503.34	4		
South Carolina.....	102,285.10	11	43,448.61	5	431,297.98	48	197,385.71	22	127,356.45	14		
Tennessee.....												
Texas.....	773,598.92	42	149,022.41	8	146,697.10	8	423,096.06	23	335,725.95	19		
Utah.....									16,501.68	100		
Vermont.....	32,455.63	20	35,381.48	22	42,879.47	27	39,203.19	24	10,674.90	7		
Virginia.....	105,745.55	15	43,069.77	6	251,940.26	36	205,705.30	29	95,065.26	14		
Washington.....	348,694.67	6	381,942.69	7	2,868,552.43	51	1,433,711.72	26	586,395.19	10		
West Virginia.....			65,972.77	12	399,848.82	73	57,073.04	10	27,791.47	5		
Wisconsin.....	263,595.56	12			1,311,298.23	55	559,890.45	23	245,918.90	10		
Wyoming.....	246,012.17	26			127,368.95	14	342,812.66	37	214,505.68	23		
Total.....	7,103,390.37	18.83	587,258.51	7.0	23,691,252.25	45.5	11,175,276.28	21.5	6,302,831.77	12.2		

¹ Explanation of items: Surfacing arranged by classes as follows: Class 1—Gravel, sand-clay, top soil shell, etc. Class 2—Macadams. Class 3—Brick, block, Portland cement concrete, and bituminous concrete. Grading includes clearing, grubbing, and excavation. Structures include bridges, culverts, drain-pipe, guardrails, retaining walls, etc.

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Projects under construction and completed.

States.	Projects under construction.	Miles under construction.	Federal aid under construction.	Total estimated cost under construction.	Per cent completed on projects under construction.	Projects completed.	Miles completed.	Federal aid completed.	Total estimated cost completed.	Amounts Federal aid paid States.
Alabama.....	14	95	\$365,993	\$1,242,501	50	45	288	\$1,238,345	\$2,524,645	\$1,352,036
Arizona.....	19	175	1,705,732	3,816,863	75	20	147	1,297,063	2,659,906	1,141,043
Arkansas.....	63	875	3,207,126	10,245,304	53	12	67	1,457,759	1,056,023	1,457,759
California.....	26	230	2,711,717	5,423,434	41	23	198	1,766,167	3,665,711	1,882,385
Colorado.....	57	283	2,653,822	4,192,462	39	37	124	918,796	1,800,644	1,235,354
Connecticut.....	3	51	928,823	2,435,932	51	1	5	108,647	125,661	108,647
Delaware.....	1	6	54,000	210,143	20	6	28	393,655	1,694,315	331,366
Florida.....	19	133	2,219,787	4,658,933	54	4	34	136,164	272,405	447,025
Georgia.....	121	838	4,334,955	10,265,001	57	61	282	2,473,282	5,334,779	4,054,811
Idaho.....	30	387	2,498,889	5,275,304	64	12	149	772,036	1,631,841	1,584,306
Illinois.....	91	334	5,246,058	12,265,218	68	122	411	5,561,818	13,574,179	6,893,718
Indiana.....	16	137	2,449,076	4,959,943	57	7	21	420,717	886,417	978,058
Iowa.....	76	1,150	6,527,056	16,193,990	53	14	168	664,850	1,616,040	1,677,133
Kansas.....	55	411	4,772,257	18,423,304	41	15	91	950,999	2,374,383	1,670,775
Kentucky.....	32	255	2,929,458	6,041,993	50	7	28	334,127	720,530	1,199,093
Louisiana.....	524	35	3,009,176	6,661,925	60	17	150	1,521,931	1,962,836	1,962,836
Maine.....	23	106	1,792,678	3,715,704	33	2	28	367,753	735,563	501,789
Maryland.....	24	60	829,936	1,864,932	48	39	103	1,377,931	2,826,002	1,477,779
Massachusetts.....	25	82	1,391,327	3,187,270	48	20	48	624,270	1,352,399	953,609
Michigan.....	280	3,954,641	8,193,921	45	23	105	931,355	1,463,609	1,463,609	1,463,609
Minnesota.....	107	1,096	4,559,714	12,834,977	60	52	649	1,970,362	5,113,061	4,391,092
Mississippi.....	36	373	2,458,754	5,075,627	45	16	120	4,421,706	805,214	982,554
Missouri.....	60	572	4,740,998	10,452,328	40	9	54	1,626,263	473,755	773,905
Montana.....	54	486	2,332,396	4,741,836	60	28	149	1,061,668	2,476,026	1,807,026
Nebraska.....	52	735	2,153,566	4,349,643	70	38	669	1,673,636	3,507,126	2,112,268
Nevada.....	12	92	941,517	1,908,789	72	15	104	1,509,490	1,063,622	796,167
New Hampshire.....	39	36	2,686,518	5,177,637	68	77	89	654,612	1,363,494	781,695
New Jersey.....	9	40	7,88,307	2,488,630	45	15	56	872,257	2,207,120	856,626
New Mexico.....	25	1,366,026	7,632,651	54	16	162	717,773	1,439,195	1,082,296	
New York.....	34	185	3,438,973	7,988,025	16	4	10	140,619	281,237	298,308
North Carolina.....	71	647	4,589,486	9,553,060	60	47	269	1,484,702	3,399,667	3,043,818
North Dakota.....	74	874	2,729,580	5,515,765	48	9	122	1,40,177	302,022	849,916
Ohio.....	404	4,976,664	1,5,319,521	35	40	182	1,829,857	5,486,628	2,815,248	2,815,248
Oklahoma.....	24	232	3,150,436	7,450,828	35	8	15	1,353,274	2,735,735	2,471,102
Oregon.....	23	298	3,054,314	6,460,001	70	22	190	1,277,854	2,649,165	1,195,829
Pennsylvania.....	56	298	6,018,133	17,106,235	54	52	254	4,739,346	5,951,488	310,571
Rhode Island.....	6	22	399,995	962,593	65	5	104	153,085	265,050	1,247,200
South Carolina.....	45	5,110,561	2,325,719	5,5,110,561	557	104	1,199,357	557	237	

NATIONAL FOREST ROADS.

The importance of the national forest road project is becoming more clearly apparent with the development of construction. Many important State and interstate highways now under improvement with Federal aid traverse the national forests, and it is seen that the development of the State systems will be incomplete until the national forest links are built. In the construction of the forest roads built up to the present time the purpose has been to develop service roads for the protection and administration of the forests, to build the more important sections of State roads in urgent need of construction, and to develop county roads in the forest areas which have been necessary for community use. It is realized, however, that the road development program in general will increasingly involve the development of the roads lying wholly or partly within the forests or adjacent thereto, as a necessary part of the comprehensive program. There are approximately 14,000 miles of main State and county roads within the forests still to be constructed, and in addition there are estimated to be about 13,000 miles of service roads, or a total of approximately 27,000 miles of highways. Adequately to construct only the roadbed for the 14,000 miles of main State and county roads will require approximately \$150,000,000. Many of these roads must be surfaced at an additional cost. Certainly by the time the improved surfaced State highways are developed outside the national forests it will be imperative that an equally good connection through the forests be provided. This need will establish certain priority of the construction of main State and county highways.

The development of the 13,000 miles of service roads must proceed simultaneously for the protection and administration of the forests and will involve in excess of \$50,000,000, as near as may be estimated. These roads will not be primarily community roads, but will be roads of the utmost importance for fire protection.

The Bureau of Public Roads has been called upon to make surveys and plans for and construct the major roads in the forest road building project. The Forest Service prepares the necessary agreements with local authorities, and these agreements become the authority of the Bureau of Public Roads for action under the amounts stipulated. Promptly after January 1, the Forest Service prepares a working program for the season's construction. This program is based upon the report of progress for the preceding year and involves the surveys of the preceding season. The construction season in many of the forests is very short. Owing to latitude, and in some cases to altitude, numerous projects can not be worked until July and must close in October. For this reason advertisements for bids are issued as early as may be in the spring in order that every day of the construction season may be fully utilized.

It is expected that the administration of this work will be greatly facilitated by the establishment of the regional office at San Francisco. This office will become the center for all operations on the forest road projects, and the deputy chief engineer in charge will be given full authority to expedite the work in the field. The immediate direction of the work will remain, as heretofore, in the six western districts, with headquarters at Portland, San Francisco,

Denver, Missoula, Ogden, and Albuquerque, at which points also are the headquarters of the corresponding forest districts.

In each of the district offices an engineer, assigned as assistant to the district engineer, has exclusive charge of the forest road construction within the district. Under him work the chiefs of survey parties and resident engineers on construction projects. A thorough system of cost reports on surveys and construction has been devised, and detailed reports of all forest road activities are made each month to the regional office, from which summary reports are forwarded to Washington. Payment on forest road contracts is made largely through the forest fiscal agents on vouchers signed by the district engineers.

During the past fiscal year a large amount of TNT has been received from the War Department and to date over 7,000,000 pounds have been used in forest road construction. The use of this explosive has effected considerable reduction in the cost of rock excavation and heavy grubbing.

Other surplus war equipment received includes automobiles, motor cycles and bicycles used for inspection, supervision, and patrol of the work; and trucks, tractors, portable engines, gas-driven hoists, rock crushers and screens, dump wagons, scrapers, pile drivers, cranes of various types, field blacksmithing outfits, a few shop tools, spare parts, and a miscellaneous assortment of supplies and material, all of which is useful in the construction and maintenance of the roads. There is still need of additional equipment of steam shovels, rock-drilling machines, and stone crushers.

All equipment and surplus war material received from the War Department as well as that purchased has been placed in the charge of an equipment division organized for that purpose. The headquarters of this division are at present located at Washington in order to facilitate the collection and distribution of equipment received from eastern camps. Much of the material received from the War Department has been subjected to hard usage and was in need of repairs and, in many cases, of rebuilding. In order to save the excessive transportation charges to western points on equipment that might not prove to be in condition for use, a receiving depot has been established near Washington and equipment from the eastern section of the country is shipped to this point, where it is inspected, sorted, and repaired. A large portion of the equipment received at this point has been redistributed.

FOREST ROAD PROGRESS.

During the fiscal year 1921 the advance in forest road construction has been greater than in any year since the beginning of the work. Labor conditions improved during the summer of 1920 and the fall lettings were at lower prices. The equipment, more of which has been available than in previous years, has been employed by the forces of the department largely in the necessary graveling of already completed or partially completed roads.

Sixty-seven projects have been completed or brought to approximate completion during the year, totaling 719 miles. Among them are several in each district that are worthy of special notice, such as the 28.5 miles of grading on the McKenzie highway across the Cascade

Mountains in district 1 and 19.3 miles between Prineville and Mitchell through the Ochoco forest, both in Oregon, and in Washington the completion of section 1 of the Lake Crescent road, which is a part of the State highway system. In district 2, which includes California, notable progress has been made on the Klamath River Canyon Road in the Klamath Forest, and about 24 miles have been opened to travel. Colorado, in district 3, has seen the practical completion of the Monarch Pass Road, 27.7 miles in length, and partial completion of the Independence Pass project. In Idaho the western section of the Lolo Pass highway leading from the Bitterroot Valley to Lewiston has been finished between Kooskia and Lowell for a distance of 22.8 miles. In Montana, district 11, there has been notable progress on the various sections of the West Gallatin project, totaling 13.4 miles. This project will eventually lead to Yellowstone Park. In district 12 the Warm River-Yellowstone project is nearly completed, leading from the Warm River in Idaho to Yellowstone in the national park. The Ephraim-Orangeville Road in Utah, about 22 miles in length, is practically completed; also 9 miles of the Heber-Fruitland project, in addition to about 27 miles previously constructed. In Wyoming the Hoback Canyon and Teton Pass Roads are finished. In district 13 large projects have been finished in New Mexico, including the Cimarron-Taos, 18 miles; the Glorieta-Panchuela, 17 miles; and the Hondo-Mescalero, 26.4 miles. In Arizona there have been completed, or practically completed, three projects of note, the Snowflake-Pine-top, 37.6 miles, a section of the Salt River-Pleasant Valley project, the total length of which is 23.8 miles, and 11 miles of the Oracle-Apache, making the completed length of this project 15 miles. Work is in progress on an additional large number of major forest roads, as will be seen by the table which follows. The end of the next fiscal year will show the completion of many of these roads.

Construction.

States.	Number of projects.	Completed prior to June 30, 1920.			Completed fiscal year 1921.			Total completed to June 30, 1921.			Under construction June 30, 1921.		
		Cost of construction.		Number of projects.	Cost of construction.		Number of projects.	Cost of construction.		Number of projects.	Cost of construction.		
		Federal funds.	Cooperative funds.		Federal funds.	Cooperative funds.		Mileage.	Federal funds.		Federal funds.	Cooperative funds.	
Alaska.	4	\$20,000	\$16,028	2	10	\$52,088	3	14	\$72,088	8	\$21,115	\$149,773	
Arizona.	2	32,359	61,724	7	55	237,589	9	65	198,746	2	54	30,181	
Arkansas.	1	64,838	20,000	1	49	67,651	20,000	83	132,480	10	68	111,000	
California.	5	256,251	40,800	4	32	690,456	62,980	59	916,710	5	26	407,521	
Colorado.	3	132,591	37,869	3	31	62,253	6	65	191,844	4	97	741,558	
Florida.	2	93,681	52,377	3	3	5,996	3	28,3	10,677	3	5,996	336,562	
Idaho.	2	112,754	92,377	6	87	431,165	452,660	8	110	543,919	6	42	
Iowa.	1	10,000	10,000	9	77	358,730	...	...	10,000	1	15	100,000
Minnesota.	4	131,115	137,756	9	10	135,000	...	80,934	13	100	10,000	50,000	
Montana.	1	172,533	255,774	1	1	35,032	33,053	1	12	489,815	2	37	
North Carolina.	1	63,906	28,150	11	102	397,909	100,009	10	118	135,000	1	21	
Nevada.	3	25	172,533	1	8	439,273	429,109	16	127	35,052	1	21	
New Mexico.	5	112,754	92,377	1	1	50,954	1,092	1	8	128,159	1	7	
Oregon.	1	29	60,678	24,587	5	75	148,761	119,680	6	104	61,805	53	
South Dakota.	1	20	208,452	189,097	5	32	200,091	385,178	10	52	50,954	1	
Tennessee.	1	11	33,059	37	3	151,169	56,147	4	48	184,228	5	48	
Utah.	1	293,1	1,414,220	914,162	67	749,3	3,449,137	1,921,922	103	1,012,4	4,863,357	59	
Washington.											2,886,084	60	
Wyoming.											3,889,454	60	
Total.											2,101,781		

Surveys and plans.

States,	Completed prior to June 30, 1920.			Completed fiscal year 1921.			Total completed to June 30, 1921.			In progress June 30, 1921.		
	Number of projects.	Miles.	Estimated cost of construction.	Number of projects.	Miles.	Estimated cost of construction.	Number of projects.	Miles.	Estimated cost of construction.	Number of projects.	Miles.	Estimated cost of construction.
Alaska.....	9	65	\$677,269	1	4	(1)	33,000	10	69	1,867,269	2	46
Arizona.....	12	302	1,941,979	2	55	\$258,001	4,941	14	357	2,159,980	1	11
Arkansas.....	2	44	159,001	3	.....	.....	.....	2	44	159,001	1	100,985
California.....	15	159	3,426,287	3	39	339,755	12,901	18	198	3,766,042	5	2,933,300
Colorado.....	9	175	1,668,010	2	41	84,946	7,000	11	216	2,509,956	1	(1)
Florida.....	2	30	96,730	.....	.....	.....	.....	2	30	96,730	1	20
Georgia.....	1	9	124,480	.....	.....	.....	.....	1	9	124,480	.....	.....
Idaho.....	5	140	571,447	5	82	594,175	15,146	10	222	1,165,622	2	116
Minnesota.....	1	30	3,061	.....	.....	.....	.....	1	30	3,061	.....	.....
Montana.....	4	44	498,115	4	15	9,528	8,3,114	8	59	3,592,643	1	27
North Carolina.....	2	17	173,533	.....	.....	.....	.....	2	173	533	1	27
Nevada.....	4	65	257,331	.....	.....	.....	.....	4	65	257,331	.....	.....
New Mexico.....	13	236	1,166,716	4	80	749,194	7,176	17	316	2,165,910	2	34
Oregon.....	22	208	3,308,682	2	10	(1)	4,276	24	224	4,508,682	2	32
South Carolina.....	1	5	60,378	.....	.....	.....	.....	1	5	60,378	.....	.....
South Dakota.....	4	69	446,450	.....	.....	.....	.....	4	69	446,450	.....	.....
Tennessee.....	1	12	130,000	.....	.....	.....	.....	1	12	130,000	.....	.....
Utah.....	6	214	753,429	2	97	355,000	13,202	8	311	1,109,429	.....	.....
Virginia.....	1	8	229,562	.....	.....	.....	.....	1	8	229,562	.....	.....
Washington.....	10	66	1,412,211	2	27	1,49,200	7,799	12	93	1,461,411	.....	.....
Wyoming.....	5	204	1,012,059	.....	.....	.....	.....	5	204	1,012,059	.....	.....
Total.....	129	2,102	18,567,750	27	450	3,281,799	78,655	156	2,558	21,849,549	17	393
												2,256,323

¹ No estimated cost of construction included for 1 project.² Includes Mariposa—Big Trees, length surveyed, 30.6 miles. Estimated cost of construction given for 18 miles only.³ Cost of surveys and plans for 3 projects not included.⁴ No estimated cost included for 2 projects.

DISTRIBUTION OF SURPLUS WAR MATERIALS, EQUIPMENT, AND SUPPLIES.

The total value of the surplus war materials equipment and supplies distributed by the bureau to the State highway departments for use in road construction is approximately \$130,000,000. The amount reported by the States as received up to July 1 is valued at \$117,110,751. This does not include the material, valued at approximately \$11,000,000, retained by the Department of Agriculture.

The beneficial effects of the distribution of this material, the value of which exceeds the total money aid actually paid to the States, can scarcely be estimated. That distributed in 1919 and 1920 enabled many States to continue some semblance of a highway construction program throughout that difficult period; and in a majority of the States the equipment received from the Government made it possible to maintain roads which otherwise would have been allowed to deteriorate because of the lack of the necessary equipment and funds with which to purchase it.

The material distributed, in addition to motor vehicles and major construction machinery, is as various as the needs of road construction under the wide range of natural conditions existing in the United States. No material has been distributed for which there is not an actual need in road building, and none has been shipped to any State except upon request by the State highway department.

In the distribution of so vast an accumulation, the shipment of a certain amount of unserviceable material is not to be avoided. Instances of this sort have been reported; and, almost invariably, the cause is found to be a faulty description of the equipment on existing inventories. That the number of such cases has been insignificant, however, is revealed by a thorough investigation, which shows that the value of the unserviceable material exchanged or sold as junk by the States has amounted to less than one-half of 1 per cent of the value of the surplus war materials distributed to all the State highway departments.

The motor trucks, in particular, have been most gratefully received by the several States. In most cases the vehicles, as received, have not been suitable for construction use, but they have been adapted by the installation of special bodies and hoisting or unloading devices at very moderate cost, and recent investigation reveals a general feeling of satisfaction with the results obtained. Most of the States have provided well-equipped shops and garages for the maintenance and protection of their equipment.

Of the miscellaneous material distributed, the large part consists of machinery, equipment, and tools commonly used in road construction. In a number of instances material especially designed for war purposes has been ingeniously adapted to other uses. For example, the bombproof shelters known as elephant shelters have been employed in the mountains of Colorado as snow shelters and in the deserts of Arizona as large culverts to protect the roads from floods resulting from the infrequent but heavy rains which visit the section.

Nearly 20,000,000 pounds of TNT intended for military demolition purposes have been diverted to construction, peaceful uses, for which it has proved so suitable that it is preferred by many blasting

experts to dynamite. Large quantities of hand grenade and other powders have also been utilized to excellent advantage.

Galvanized corrugated iron has been employed to build shops, garages, and offices the windows of which, in at least one case, have been shaded by awnings ingeniously contrived from surplus automobile tops.

In one case which has been reported, pipe received from the Government was used to carry compressed air from the compressors to the drills used in the excavation of the foundations of a bridge, and the same pipe was afterward employed as the guard rail on the bridge.

It is believed that by October 31 the material of all sorts delivered to the States will amount to a value of \$150,000,000. So far as possible the distribution of this material has been made in accordance with the same formula which governs the allotment of the Federal-aid funds. That is has not been so distributed in every case is due to the fact that some of the States have not found it desirable to accept their full share. The value of the material which is due to each of the States on the basis of \$150,000,000, and the approximate values delivered up to June 30, are shown in the table which follows:

State.	Value to each State on basis of \$150,000,000 distribution.	Approximate value delivered July 1, 1921.	State.	Value to each State on basis of \$150,000,000 distribution.	Approximate value delivered July 1, 1921.
Alabama.....	\$3,255,000	\$2,587,740	Nevada.....	\$1,995,000	\$1,182,300
Arizona.....	2,115,000	2,041,401	New Hampshire.....	645,000	412,500
Arkansas.....	2,595,000	2,025,000	New Jersey.....	1,845,000	1,657,900
California.....	4,710,000	3,687,500	New Mexico.....	2,475,000	2,133,440
Colorado.....	2,685,000	2,527,640	New York.....	7,695,000	5,509,520
Connecticut.....	945,000	643,500	North Carolina.....	3,525,000	3,093,920
Delaware.....	255,000	412,500	North Dakota.....	2,370,000	1,477,350
Florida.....	1,770,000	1,483,900	Ohio.....	5,730,000	4,194,900
Georgia.....	4,170,000	4,271,600	Oklahoma.....	3,570,000	2,112,000
Idaho.....	1,890,000	1,474,000	Oregon.....	2,145,000	1,662,000
Illinois.....	6,765,000	5,462,400	Pennsylvania.....	7,095,000	4,354,600
Indiana.....	4,170,000	2,942,920	Rhode Island.....	360,000	229,900
Iowa.....	4,470,000	2,871,900	South Carolina.....	2,220,000	1,768,820
Kansas.....	4,440,000	2,591,600	South Dakota.....	2,505,000	2,365,900
Kentucky.....	3,015,000	2,011,900	Tennessee.....	3,495,000	3,156,500
Louisiana.....	2,100,000	1,472,100	Texas.....	9,045,000	7,101,240
Maine.....	1,185,000	973,500	Utah.....	1,755,000	1,333,500
Maryland.....	1,350,000	1,056,160	Vermont.....	705,000	529,100
Massachusetts.....	2,280,000	899,800	Virginia.....	3,075,000	2,920,800
Michigan.....	4,470,000	4,648,320	Washington.....	2,235,000	1,391,500
Minnesota.....	4,395,000	3,190,100	West Virginia.....	1,650,000	2,254,400
Mississippi.....	2,775,000	3,273,320	Wisconsin.....	3,930,000	3,042,000
Missouri.....	5,250,000	3,669,800	Wyoming.....	1,890,000	1,230,900
Montana.....	3,090,000	2,400,400	Total.....	150,000,000	¹ 117,110,751
Nebraska.....	3,300,000	3,347,660			

¹ Does not take into consideration 10 per cent of the equipment retained by the Department of Agriculture.

The values of the major classes of material delivered are as follows: Machinery, equipment, and supplies, \$30,648,759; motor vehicles, \$74,730,568; spare parts, \$11,731,424.

The number of motor vehicles allotted and distributed to July 1, and the amount of other material distributed to September 15, are shown in the two tables which follow:

Allotments and deliveries of trucks, Fords, and automobiles from surplus war materials to the several States, and retained by Department of Agriculture, to July 1, 1921.

State.	Total vehicles allotted.	Trucks delivered.	Fords delivered.	Autos delivered.	Total vehicles delivered.	Per cent. delivered.
Alabama	562	439	55	3	497	88
Arizona	366	277	22	3	302	82
Arkansas	450	390	57	10	457	-----
California	816	601	75	14	690	85
Colorado	465	377	40	5	422	91
Connecticut	163	123	15	3	146	90
Delaware	44	50	7	5	62	-----
Florida	307	235	33	5	273	89
Georgia	722	580	123	10	723	-----
Idaho	323	271	24	8	303	93
Illinois	1,172	910	110	23	1,043	89
Indiana	722	561	81	10	652	90
Iowa	776	596	65	4	665	86
Kansas	770	606	81	5	692	90
Kentucky	520	404	49	6	459	88
Louisiana	364	278	36	7	321	88
Maine	260	177	25	3	205	79
Maryland	234	208	15	5	223	97
Massachusetts	395	201	23	2	226	57
Michigan	776	656	76	11	743	96
Minnesota	760	582	54	6	642	85
Mississippi	480	378	46	6	430	90
Missouri	910	680	69	11	760	84
Montana	535	397	42	4	443	83
Nebraska	570	439	63	8	510	89
Nevada	345	218	20	6	244	71
New Hampshire	112	96	10	2	108	96
New Jersey	320	299	56	13	368	-----
New Mexico	330	341	29	-----	373	87
New York	1,333	1,014	124	12	1,150	86
North Carolina	610	471	76	5	552	91
North Dakota	410	299	30	4	333	81
Ohio	992	782	95	21	899	91
Oklahoma	620	455	43	4	502	81
Oregon	424	304	28	6	338	80
Pennsylvania	1,229	837	113	23	973	79
Rhode Island	62	45	3	2	50	81
South Carolina	385	303	41	5	349	91
South Dakota	435	324	46	4	374	86
Tennessee	606	462	75	7	544	90
Texas	1,567	1,176	127	34	1,337	85
Utah	304	238	22	1	261	86
Vermont	122	96	7	2	105	86
Virginia	530	390	48	10	448	85
Washington	390	302	37	7	346	89
West Virginia	286	224	21	6	251	88
Wisconsin	680	459	47	15	521	77
Wyoming	326	229	24	4	257	79
Agriculture	2,000	1,336	368	72	1,776	89
Total and average	27,983	21,124	2,787	442	24,353	87

Surplus war materials, except motor vehicles and equipment, received by the States up to September 15, 1921.

Acid:

Hydrochloric.....

boxes.....

7

Picric.....

pounds.....

267,600

Adzes, with handles.....

.....

88

Angles, bridge.....

.....

3,504

Anvils.....

.....

30

Aprons.....

.....

97

Arms, cross.....

.....

50

Arrows, steel.....

.....

11

Augers.....

.....

290

Axes, various kinds.....

.....

30,341

Asphalt.....

.....

5

Axes, dump wagon.....

.....

9

Babbitting, tractors.....

sets.....

34

Bags, various kinds.....

.....

9,706

Balls.....

.....

1

Barometers.....

.....

93

Bars:

Crow.....

.....

1,553

Wrecking.....

.....

215

Grate.....

.....

25

Timber, octagon.....

.....

17

Bars—Continued.

Rock, drill, assorted.....

32

Lining, diamond point.....

129

Chisel, 18-inch.....

5

Slicing.....

3

Digging.....

112

Finch.....

367

Cement.....

13

Claw.....

61

Splice, for 25-pound rail.....

pairs..

126,497

Steel, assorted.....

pounds..

34,727

Beams:

Floor, bridge.....

336

I.....

19

Beams, plow.....

6

Bearings, assorted.....

23

Bells.....

5

Belting, assorted.....

13

Benches.....

1

Bender, rail.....

6

Bits, assorted.....

13

Black, lamp.....

100

Surplus war materials, except motor vehicles and equipment, received by the States up to September 15, 1921—Continued.

Blades, assorted	94	Carts—Continued.	
Blocks:		Concrete, miscellaneous	1,200
Swage, blacksmith	49	Sanitary, 2-wheel	14
Wood	450	Ration, 2-wheel	6
Iron	64	Catiking	coils
Chain	2	Cases, file	3
Cargo	27	Cement	bags
Miscellaneous	550	Chains:	
Steel	224	Towing	96
Snatch	89	Iron	65
Blower, assorcd	10	Assorted sizes	feet 4,891
Board, molding, with pair of handles	1	Conveyor	sections 3
Bob, plumb, various types and sizes	305	Surveyors, assorcd	39
Bodies:		Stanley hook skid	5,180
Western dump-car	9	Autishill	5,949
G. M. C.	1	Extra for tongs	8
Puckard	6	Chests, assorcd	1,315
Nash	23	Chisels, assorcd	1,562
Dodge	7	Clamps, concrete pouring	feet 200
White	11	Clamps, various sizes	21,485
Cargo, 3-ton	327	Cleaner metal	barrels 41
Iron cart, 2-way dump	3	Climbers	pairs 61
Flat car	4	Clips, miscellaneous	2,000
Ford delivery	434	Clock	1
F. W. D.	60	Clotn, emery	75
Truck, 1-ton	8	Clutches, miscellaneous	box 1
Boilers, various kinds	42	Compasses, various sizes	1,553
Bolts:		Compensator	1
Bridge	15,788	Conveyor	sections 551
Railroad	kgs. 111	Do	feet 1,000
Boots, rubber	pairs 11	Cord:	
Boxes:		Detonating	feet 117,350
Axles for Western dump cars	10	Countershaft	1
Engineer's transit	3	Couplings	3
Truck tool	52	Countersinks, nail	424
Braces:		Covers, miscellaneous	12,776
Bit	222	Cranes, various sizes	83
Carpenters	75	Crayons	box 1
Rail	3,527	Do	crates 2
Trench	187	Cross s. cast iron	2
Brackets, extinguisher	92	Crucibles	boxes 7
Breakers, road	6	Crusher, miscellaneous	25
Bridges, steel highway	1	Cups, oil and grease	33
Brooms, various kinds	12,393	Curves, railroad amber	set 1
Brushes, paint	50	Cutter, assorcd	707
Buckets:		Derailer, car, iron	14
Clamshell	152	Derrick, miscellaneous	197
Orange peel	127	Desks:	
Fire	4,205	Field	1,108
Concrete mixer, loading	4	Office	1
Dump	9	Detectors, circuit	693
Buggies:		Detonators, Nos. 6 and 8	93S, 409
Ammenta	60	Diggers post hole	404
Concrete	349	Disk, farmer	3
Burners	31	Ditcher	1
Cab, Ford	3	Dividers	1,013
Cable:		Dollies, miscellaneous	108
Assorted	feet 275,055	Drag, miscellaneous	20
Do	pounds 4,316	Dray	1
Do	coils 40	Drills, miscellaneous	1,386
Do	reels 7	Driver, miscellaneous	9
R. C. high-tension, 19-strand	feet 15,000	Dynamite, 60 per cent freezing	6,506
Assorted	pounds 1,502	Fdry	1
Cabinet, miscellaneous	4	Ells, various sizes	895
Cake:		Elevators, Jeifery link-belt	2
Carbide	drums 8	Emery	pounds 90
Do	cans 127	Engines:	
Calipers	95	Center crank	1
Cameras, 3½ by 5½	60	Hoisting, miscellaneous	124
Cans, assorted	1,228	Case	4
Caps, blasting, electric	75,968	Gas, various sizes	390
Carbide, calcium	cans 9	Steam, various sizes	19
Carpenter shops, portable	10	Portable, various sizes	3
Carriers, miscellaneous	565	Equipment, gravel pit	lot 1
Cars:		Excavators	2
Dump, miscellaneous	204	Explanders, roller tube	3
Standard steel cradle	6	Exploders	131,674
Keppel, 3 cubic yards	14	Extinguishers, assorcd	1,129
Flat, miscellaneous	552	Fans	1
Low-side gondola	739	Files	3,730
Standard push No. 6	31	Floats, cement	4
Carts:		Forges, miscellaneous	1,956
Lumber, 36-inch gauge	16	Forks, assorted	431
Two-wheeled dump, one-horse	61	Forms, road concrete	262
Two-wheeled water, 150-gallon	345		
Log	18		

Surplus war materials, except motor vehicles and equipment, received by the States up to September 15, 1921—Continued.

Frames, miscellaneous.....	634	Outfits, miscellaneous.....	10
Frogs, No. 8, 25-pound rail.....	204	Packing, assorted sizes.....	sheets 1,267
Furnace, assorted.....	84	Do.....	pounds 1,318
Fuse.....	feet 27,840	Paper, sand, No. 2, sand and emery.....	sheets 15,802
Gaskets, rubber.....	517	Parts, spare:	
Gauge, assorted.....	2,671	Auto car.....	lot 1
Gears, lumber wagon.....	101	Bethlehem.....	do 1
Generator, Delco, 3-kilowatt.....	sets 21	Buick.....	lots 16
Girders, bridge.....	562	O. P. buckets.....	do 16
Globes, assorted.....	1,528	Car, 36-inch gauge.....	cases 531
Graders, miscellaneous.....	53	Diamond T.....	lot 1
Grease, graphite.....	cans 1,279	F. W. D. brackets for tops.....	598
Grinder, assorted.....	444	F. W. D. tops with curtains.....	598
Grapples, timber.....	30	Ford.....	lots 104
Grindstone.....	24	93 horsepower gas engine.....	do 6
Grovers.....	2	G. M. C.....	do 11
Grousers.....	430	Heavy aviation, 3-ton.....	do 76
Grubbers, bush.....	33	Hudson Supersix.....	do 11
Guards.....	2	International 2-ton.....	do 38
Guides.....	1	Locomotive, 36-inch gauge.....	do 50
Gun, Boe, assorted.....	12	Kelly-Springfield.....	do 18
Frames, under car.....	105	Moreland.....	do 9
Hammers, assorted.....	4,660	Nash, 2-ton.....	do 392
Handbook:		Nash tops and curtains.....	sets 408
Heavy aviation.....	167	Overland.....	lots 14
F. W. D.	30	Packard.....	do 92
Nash Quad.....	195	Pierce Arrow.....	do 120
Handles, assorted.....	73,009	Selden.....	do 12
Hangars, assorted.....	342	Service.....	do 2
Harness.....	sets 16,078	Holt tractor, 75 horsepower.....	do 1
Harrows, disk.....	8	Cleveland tractor.....	do 2
Hatchets.....	1,999	Trailer, 15-ton.....	cases 25
Hods.....	crate 1	Velie.....	lots 9
Hoes, miscellaneous.....	1,864	Vim.....	do 1
Heater, surface.....	1	Whites, 5 and 3 ton.....	do 13
Hoists, miscellaneous.....	322	Wilson.....	do 2
Hooks, assorted.....	1,741	Atterbury.....	units 3
Hoppers, assorted.....	8	Brockway.....	do 3
Horses, pack.....	12	Crane, various types.....	lots 12
Hose, various kinds and sizes.....	pieces 19	Chalmers.....	do 4
Do.....	sections 3	Chandlers.....	do 3
Do.....	feet 382,282	Chevrolet.....	do 2
Houses, observation.....	13	Cole.....	do 1
Iron:		Commerce.....	do 5
Angle, assorted.....	160	Cook, gas engine.....	sets 33
Soldering.....	314	Dort.....	lots 2
Corrugated, 16 gauge, 27½ by 24 inches,.....	sheets 5,096	Federal.....	do 4
Digging.....	82	F. W. D. miscellaneous.....	do 1
Jacks, various sizes.....	1,814	Gramm-Bernstein.....	do 11
Jaws, rock crusher.....	52	Grant.....	do 1
Jointers.....	263	Garford.....	do 9
Joints, elastic expansion.....	feet 10,260	Haynes.....	do 1
Kettles, tar and melting.....	40	Light and heavy aviation.....	do 105
Lamps, assorted.....	6,356	Steam hoist, 7 by 10.....	cases 35
Lampblack.....	pounds 1,000	Hurlbut.....	lots 2
Knives.....	712	Hupmobile.....	do 3
Lanterns, assorted.....	31,025	Indiana.....	do 1
Lathes, assorted.....	133	Jeffery.....	do 4
Legs, for wheelbarrow.....	34	Kissel.....	do 1
Levels, assorted.....	2,376	Light aviation.....	do 20
Lights, assorted.....	958	Lippard-Stewart.....	do 1
Line, chalk.....	feet 29,500	Mack.....	do 1
Loaders, miscellaneous.....	2	Maxwell.....	do 4
Lockers, miscellaneous.....	13	Miscellaneous.....	do 70
Locomotives, various sizes.....	172	Cleveland motor cycle.....	do 9
Lubricator, Detroit.....	14	National.....	do 6
Machines, various kinds.....	1,703	Nash wood bows for tops.....	1,332
Magnet, lifting and control device.....	2	Oakland.....	lots 4
Mallets, mattocks, mauls, assorted.....	10,816	Oldsmobile.....	do 3
Metal, various sizes.....	carloads 35	Pearless.....	do 36
Do.....	rolls 1,074	Reo.....	do 22
Do.....	sheets 9,261	Republic.....	lots 9
Do.....	2,229,538	Riker.....	do 11
Meters.....	36	Sawmill.....	do 2
Micrometers.....	sets 14	Saxon.....	do 3
Mill, crushing, Allis-Chalmers, 2-roll.....	1	Shovel, Osgood.....	do 1
Mills, saw.....	11	Standard.....	do 4
Mixers, concrete, miscellaneous.....	282	Studebaker.....	do 19
Motors, various horsepower.....	210	Holt tractor, 15-ton.....	do 16
Movers, car.....	4	Holt tractor, 20-ton.....	do 33
Mowers.....	10	Gray wide drum.....	do 8
Nails, finishing, 6-penny, 100 pounds per keg,.....	kegs 325	Trailer, 5-ton, 4-wheel revolution.....	do 5
Neck, goose reflector.....	1	United.....	do 1
Nipples, assorted sizes.....		Wagon, escort.....	sets 3,000
		Willys Knight.....	lots 3
		Pads, collar.....	1,200

Surplus war materials, except motor vehicles and equipment, received by the States up to September 15, 1921—Continued.

Pants, men's wading.....	259	Spokes, wagon.....	402
Paste, soldering.....cans.	341	Sprayers.....	81
Paulins, canvas.....	35	Squares, assorted.....	1,096
Peavies, with and without handles.....	18	Squibbs, electric.....	149,464
Pencils.....	1,055	Stand, miscellaneous.....	1,339
Picks, assorted.....	35,133	Starter.....	10
Piling, creosoted, 35-foot length.....pieces.	60	Steel, assorted.....sheets.	18
Pins, marking, surveyors', etc.....	164	Do.....tons.	270
Pipe, assorted sizes and types.....feet.	762,467	Do.....pieces.	4,500
Planes, assorted.....	372	Do.....pounds.	79,220
Planimeters.....	131	Stepladders.....	6
Plants:		Stocks, assorted.....	8
Asphalt.....	12	Stocks and dies.....sets.	406
Rock screening.....	1	Stone, crushed.....cubic yards.	18
Plates, assorted.....	1,420	Stools.....	45
Pliers.....	122	Stops, benches.....	5
Plow, assorted.....	231	Stoves, miscellaneous.....	419
Plugs, spark.....	47,900	Straight, edge steel, 36-inch.....	7
Points, switch:		Stringers, bridge.....	1,429
25-pound rail, right-hand.....	286	Struts, bridge.....	17
25-pound rail, left-hand.....	237	Switches, miscellaneous.....	1,627
Poles, various types.....	945	Tables, miscellaneous.....	377
Posts, fence.....	307,647	Tampers, miscellaneous.....	198
Pots, fire, melting, etc.....	121	Tanks, various kinds.....	776
Powder:		Tapes, electric.....pounds.	765
Miscellaneous.....pounds.	78,587	Taps and dies, assorted.....sets.	62
Black blasting No. 3F.....do.	1,798,988	Tape, various kinds.....	2,505
Hand grenade, etc.....do.	2,781,313	Tarpaulin.....	1
Press, various kinds.....	29	Tees, assorted.....	401
Pullers, assorted.....	39	Teeth, clamshell bucket.....set.	1
Pulleys, assorted.....	918	Tender, locomotive, 36-inch gauge and parts.....	19
Pumps, various kinds and sizes.....	6,973	Tents, miscellaneous.....	6,053
Punches, assorted.....	18	Ties, assorted.....	19,075
Radiators.....	28	Do.....feet.	34,134
Rail:		Tighteners, universal clamp.....	100
Various kinds and sizes.....feet.	29,206	Tires, auto.....lots.	316
Do.....pieces.	1,704	TNT.....pounds.	19,613,295
Do.....gross tons.	16,742	Tongues, wagon.....	15
Guard, 25-pound, without filler.....	573	Tongs, miscellaneous.....sets.	97
Rakes, various kinds.....	214	Do.....do.	228
Ranges, cook, Nos. 1 and 2.....	1,295	Tools, miscellaneous.....	146
Ram, hydraulic.....	1	Torches, blow.....	32
Revelators.....	1	Track, assorted.....lots.	11
Rods:		Tractors, various types.....	1,757
Level.....	677	Trailers, various types.....	1,272
Connecting switch stands.....	81	Transformers.....	19
Sway for bridge.....	92	Transits, various types.....	239
Rollers, various kinds.....	60	Transveyors.....	2
Roofing, metal.....sheets.	888,907	Trays, wheelbarrow.....	96
Do.....bundles.	189,435	Trees, single and double.....	229
Rope, various kinds and sizes.....feet.	494,863	Trestle, conveyor, adjustable.....	4
Do.....pounds.	32,642	Triangle, assorted.....	3
Do.....coils.	242	Tripods.....	1
Rosin.....boxes.	2	Trolleys:	
Rubber sheets.....do.	5	Assorted.....	184
Salamanders.....	65	I beam.....	7
Saws, various kinds.....	26,375	Trowels, various sizes.....	463
Scales, assorted.....	99	Trucks, assorted.....	68
Scarfier, Acme road.....	2	Turnouts, railroad, 36-inch gauge, 25-pound	
Scrapers, assorted.....	1,296	rail.....	509
Screen, sand and rock.....	150	Turntable, 24-inch gauge.....	7
Screw drivers.....	1,034	Tubing.....feet.	411
Seats, Federal.....	2	Do.....pieces.	8
Sections, truss bridge.....	100	Unions, 2-inch.....	98
Setters, tire.....	27	Valves, assorted.....	875
Shafting, miscellaneous.....lots.	8	Vices, various kinds.....	640
Shaper, Barker.....	1	Vulcanizing outfits.....	1
Shaves, spoke.....	390	Wagons, various kinds.....	4,773
Sheaves.....	76	Washers, bridge (bolt and lag screws).....	4,873
Shellac.....	1,268	Welding equipment, acetylene.....boxcs.	25
Shovels, various kinds.....	363,006	Wheelbarrows, various.....	7,960
Screws, bridge and miscellaneous.....	14,674	Wheels, wheelbarrow.....	5
Shakers, cement bag.....	5	Whetstones, scythe.....	23
Shares, plow.....	6	Wire, various kinds.....spools.	6,556
Shelters:		Do.....feet.	43,281
Trench.....	9,848	Do.....tons.	1,659
Elephant steel.....	2,430	Do.....pounds.	553,748
Sledges, miscellaneous.....	1,758	Do.....carloads.	2
Scythe.....	238	Winches, assorted.....	280
Spades, miscellaneous.....	33,786	Wrenches, assorted.....	489
Slings, canvas.....	75	Wheels, emery, assorted.....	422
Spikes, miscellaneous.....	207,778	Wicking.....pounds.	30
Snips, tinnery.....	519	Windlass, hand power.....	1

ROAD-MATERIAL TESTS AND RESEARCH.

The work of the division of tests has been continued with a degree of expedition commensurate with the need. The emphasis which has been laid upon those researches which are expected to throw light upon questions of road design has been due to the importance of the problems to be solved.

Several important investigations have been practically completed and full advance reports have been published in *Public Roads*, the monthly magazine published by the bureau. These reports include the results obtained from a study of impact of motor trucks on roads, a study which is very enlightening, as it shows the relative impact to be expected from different weights of motor trucks when equipped with different kinds of tires and when traveling at different speeds. A second report deals with the completed investigation on accelerated wear tests in which 49 road surfaces were subjected to identical traffic and the relative wearing qualities determined. Still a third report has been prepared, but not yet published, dealing with the effects of impact on a large number of road surfaces of different design. Other important investigations are under way, notably a series of field investigations of methods of draining road subgrades and a study of the physical and chemical properties of subgrade materials made with the idea of standardizing tests to determine the value of subgrade materials and also with the idea of determining how to change the characteristics of subgrades having poor supporting value.

A number of different papers have been presented at various times during the year as a result of these investigations. These papers are listed as follows:

1. Tests for Soils with Relation to Their Use in the Subgrade of Highways.
2. Highway Researches and What the Results Indicate.
3. Application of Loads, Traffic Intensity, Speed and Subgrade Conditions to the Design of Road Surfaces.
4. Investigations of Road Subgrades.
5. The How and Why of Motor Truck Impact.
6. The Mutual Adaptation of the Motor Truck and the Highway.
7. The Measurement of Impact.

CONCRETE INVESTIGATIONS.

The concrete investigations during the past year have included an investigation of the effect of alkali mixing water on the strength of concrete. In addition, preliminary tests have been made to develop protective treatments for concrete drain tile subjected to alkali waters. An investigation of the strength of concrete mixed at a central mixing plant and hauled by motor truck for various periods of time has likewise been made. Investigations of slag as an aggregate in concrete have been continued.

NONBITUMINOUS ROAD MATERIAL INVESTIGATIONS.

An investigation of the chemical limitations of blast-furnace slag which may safely be used as a concrete aggregate has been made, and the results of the investigation have been presented in a paper before the American Society for Testing Materials, entitled "A Study of the Composition of Blast Furnace Slags Suitable for Concrete Aggregate."

A very comprehensive survey of the sand and gravel producing plants of the eastern and central portions of the country has been made, and the results have been published in *Public Roads*, entitled "Sand and Gravel Production Survey of Twenty-two States."

In connection with a study of subgrade soils, a test has been standardized for measuring the colloidal content by means of the adsorption of dye.

An inspection of a large number of brick roads laid on macadam bases was made in the State of Ohio, and as a result of this inspection a report has been prepared which will shortly be published.

PHYSICAL TESTS OF ROAD-BUILDING MATERIAL.

During the year 2,618 samples of nonbituminous materials were examined in the physical laboratory, an increase over the previous year of 1,592, or 155 per cent. These samples were classified by types as follows:

Rock.....	451	Slag.....	69
Sand.....	1,016	Brick.....	20
Gravel.....	365	Miscellaneous.....	258
Cement.....	226		
Concrete.....	213	Total.....	2,618

Samples were received from every State in the Union with the exception of Utah, Washington, and Wyoming, and also from Canada and Mexico. The samples examined are classified geographically as follows:

Alabama.....	39	New Hampshire.....	3
Arizona.....	10	New Jersey.....	21
Arkansas.....	109	New Mexico.....	11
California.....	145	New York.....	41
Colorado.....	11	North Carolina.....	77
Connecticut.....	15	North Dakota.....	9
Delaware.....	5	Ohio.....	313
District of Columbia.....	7	Oklahoma.....	128
Florida.....	40	Oregon.....	8
Georgia.....	31	Pennsylvania.....	138
Idaho.....	1	Rhode Island.....	1
Illinois.....	96	South Carolina.....	77
Indiana.....	80	South Dakota.....	30
Iowa.....	59	Tennessee.....	63
Kansas.....	25	Texas.....	209
Kentucky.....	29	Utah.....	0
Louisiana.....	102	Virginia.....	128
Maine.....	10	Vermont.....	4
Maryland.....	48	Washington.....	0
Massachusetts.....	56	West Virginia.....	27
Michigan.....	72	Wisconsin.....	124
Minnesota.....	132	Wyoming.....	0
Mississippi.....	35	Unidentified.....	11
Missouri.....	11	Canada.....	5
Montana.....	13	Mexico.....	1
Nebraska.....	7		
Nevada.....	1	Total.....	2,618

MICROSCOPIC EXAMINATION AND CLASSIFICATION OF ROAD-BUILDING ROCK.

One thousand nine hundred and seventy samples of road material were examined by the petrographic laboratory during the year, an increase of 128 per cent over the number for the preceding year. Of these samples 497 were rock, 43 slag, 363 gravel, 939 sand, 125 clay, and 3 miscellaneous.

RESEARCH ON DUST PREVENTIVES AND ROAD BINDERS.

A number of investigations on bituminous materials have been under way during the year:

1. An investigation of the characteristics of petroleum products as affected by refinery procedure. In these investigations typical petroleums used in the manufacture of road oils and asphalts have been refined by blowing processes, making four variations of the conditions of blowing. Examination of a large number of samples has developed important information on the effects of these processes.

2. Exposure tests on road oils and asphalts. In order to study the effects of weathering and atmospheric exposure, 16 typical samples have been investigated, and the changes taking place from month to month have been studied.

3. An investigation of the fixed carbon test for petroleum and asphalt products. For the purpose of studying the significance of this test, a thorough study of the variables entering into the determination has been carried on during the year and is still in progress.

4. A comparison of the volatilization tests at present in use on fluid road materials. Two variations of this test are in general use, and a study of comparative results is underway.

5. Tests for bituminous emulsions. A beginning has been made in the development of satisfactory tests for these materials for which it is difficult to obtain reliable and satisfactory test data. This work will be continued during the coming year.

6. A study of the density and voids in compressed bituminous mixtures is being conducted to secure data relative to the application of these tests to surface mixtures as applied in road construction.

7. An investigation of the effect of alkalies on asphalts has been started, prompted by the fact that in some sections of the country road surfaces are subject to the action of strongly alkaline soils.

ROUTINE CHEMICAL TESTING AND INSPECTION.

Six hundred and thirty-eight samples were examined in the chemical laboratory, consisting of 451 samples of bituminous material, 145 samples of metal, and 42 samples of miscellaneous materials. The total number of samples examined shows a decrease of 18.5 per cent from the total number of samples examined in the preceding fiscal year, due chiefly to the fact that an unusually large number of samples of culvert pipe were examined in the preceding year in connection with the spelter coating investigation. The total number of samples of bituminous material, however, shows an increase of 23.5 per cent over the total number tested in the preceding year, notwithstanding the fact that the total number of samples for this year does not include any of the samples from refineries, whereas the total number examined in the preceding year did include refinery samples.

STANDARDIZATION OF METHODS OF TESTING NONBITUMINOUS ROAD MATERIALS.

Studies were continued on the standardization of methods of testing subgrade materials, as a result of which a paper has been presented before the American Society for Testing Materials describing these methods. In addition, field methods for testing the bearing value of subgrades have been developed and are now being standardized.

STANDARDIZATION OF METHODS OF TESTING BITUMINOUS ROAD MATERIALS.

Cooperation with committees of the American Society for Testing Materials and of the American Association of State Highway Officials has been continued. Standardization of methods is very largely cooperative work, and work has been done during the year on the following tests:

Viscosity and float test.

Penetration test.

Flash and burning point test.

Determination of water in bituminous material.

FEDERAL-AID WORK.

Eighteen hundred and twenty samples of materials from various Federal-aid projects were examined in the physical, chemical, and petrographic laboratories, an increase of 945, or 108 per cent, over the previous year. Test reports numbering 57,281 submitted by laboratories throughout the country on samples of materials used in Federal-aid work were examined, an increase of 32,296 over the previous year, or approximately 130 per cent. The attached table gives the geographical distribution of Federal-aid reports received and samples examined. A number of specifications proposed for use in Federal-aid construction were also examined and recommendations were made regarding those parts of the specifications dealing with materials.

Federal-aid samples and reports received from States for fiscal year 1921.

State.	Reports.	Samples.	State.	Reports.	Samples.
Alabama.....	1,165	22	Nevada.....	547	0
Arizona.....	401	15	New Hampshire.....	258	2
Arkansas.....	13	121	New Jersey.....	1,061	4
California.....	263	1	New Mexico.....	171	11
Colorado.....	542	10	New York.....	75	0
Connecticut.....	15	1	North Carolina.....	3	92
Delaware.....	0	0	North Dakota.....	7	43
Florida.....	489	37	Ohio.....	1,534	297
Georgia.....	3,820	7	Oklahoma.....	304	214
Idaho.....	0	2	Oregon.....	421	2
Illinois.....	9,180	48	Pennsylvania.....	2,732	13
Indiana.....	2,060	8	Rhode Island.....	31	0
Iowa.....	15,128	0	South Carolina.....	297	101
Kansas.....	3,315	10	South Dakota.....	224	70
Kentucky.....	591	39	Tennessee.....	322	21
Louisiana.....	10	128	Texas.....	1,459	208
Maine.....	184	0	Utah.....	1,424	33
Maryland.....	0	23	Vermont.....	36	0
Massachusetts.....	513	13	Virginia.....	586	91
Michigan.....	944	8	Washington.....	1,504	0
Minnesota.....	1,193	6	West Virginia.....	289	1
Mississippi.....	1,124	7	Wisconsin.....	1,025	81
Missouri.....	563	0	Wyoming.....	505	0
Montana.....	204	20	Total.....	57,281	1,820
Nebraska.....	749	1			

INSTRUMENT MAKING AND REPAIRING.

The machine shop has been kept unusually busy in the manufacture and repair of instruments used in testing. A number of important devices have been constructed, among them being an autographic device for measuring the impact of trucks and a field device for measuring the bearing resistance of soils. A number of soil pressure cells for measurement of pressure in subgrades have

been assembled, and also preliminary devices for the measurement of impact stresses in bridges have been fitted up and are now being completed. A new hardness machine has been started. A large number of repair jobs have been completed, involving instruments for testing, testing machines, a steam roller, and miscellaneous surveying equipment.

INSPECTIONS, ADVICE, AND REPORTS.

At the request of the California Highway Commission, the bureau undertook an impartial study of the work and accomplishments of the commission. This was one of the most important single projects carried on during the year. Every mile of State highway was carefully inspected to record the condition of the roads; traffic was counted at over 100 points in the State; the books of the commission were audited; and these studies with others of an economic nature were covered in a report which was published by the California commission. The report showed that criticism directed at the work of the commission was largely unfounded, though in several points it recommended changes in policies and methods. Aside from its value to the State, the study attracted widespread interest among highway engineers.

Less intensive investigations of road conditions were made for the Cholocco, Pine Ridge, and Standing Rock Indian Reservations and for the city of Morrillton, Ark., and reports were rendered in each case giving advice in regard to the special problems studied.

Requests for the assignment of an engineer to assist local authorities in the preparation of plans for contemplated highway construction were received from seven localities. These requests were referred to the respective district engineers for attention.

Designs for bridges were prepared as follows: Kansas, 1; Wisconsin, 1.

Engineers were assigned to investigate proposed bridge structures, as follows: Illinois-Iowa, 1; South Carolina, 1. The assignment to Illinois was for the purpose of investigating the present bridge and sites for a new bridge over the Mississippi River.

The bureau is cooperating with the State highway departments in the study of highway bridge requirements for the purpose of framing a set of standard requirements for highway bridge specifications of sufficient scope so that they will be adopted by all the State highway departments.

Plans have been prepared for several forest road bridges, adapting the surplus war material which was transferred from the War Department to the Department of Agriculture.

FIELD EXPERIMENTS.

Maintenance was continued on approximately 12 miles of experimental roads which had been constructed during previous years in Alexandria and Fairfax Counties, Va., in Montgomery County, Md., and in the Department of Agriculture grounds. In addition, new experiments were undertaken in the department grounds, involving the resurfacing and surface treatment of 10,550 square yards of existing asphalt road with tars and asphalts. All roads in the grounds are now included in these experiments.

The work on Bradley Lane and North Kensington Road in Montgomery County, the Russell Road in Alexandria County, and the older experiments in the department grounds was confined to routine maintenance.

Sections 3 and 4 of Mount Vernon Avenue between Washington and Alexandria were resurfaced, and the rest of the road was put into satisfactory condition by ordinary maintenance.

On the Mount Vernon Road, south of Alexandria, 4,710 feet were resurfaced and 6,140 feet were maintained without resurfacing.

The larger part of South Kensington Road, from the District line to Bradley Lane, was maintained by ordinary methods, but it was necessary to resurface sections 9 and 10, both surface-treated waterbound macadam roads.

Accurate cost data were kept on the maintenance work performed on all these roads.

EXTENSION ACTIVITIES.

MODELS AND EXHIBITS.

Exhibit material prepared by the bureau to illustrate its various activities was sent by the Office of Exhibits as a part of the combined department exhibit to 32 fairs of State or interstate importance. To reach these fairs, six separate sets of material were required, including models of various types of roads and bridges, models illustrating the proper arrangement of farm buildings and methods of preventing erosion of soil by terracing, samples of various materials used in highway construction, and large oil-colored photographs of roads and farm drainage, irrigation and rural engineering subjects.

In addition to the displays made at these fairs, special exhibits were prepared for use at a fair at Tyler, Tex., September 28 to October 2, inclusive, and at the annual conventions of the American Association of State Highway Officials at Washington and the American Road Builders' Association at Chicago. These conventions were held December 13 to 16 and February 8 to 12, respectively.

Other material was sent to the following fairs, meetings, etc., the applicant in each case defraying all expense incurred for shipping, installing, and returning the material to the bureau:

Western North Carolina Apple Show, Asheville, N. C., October 27 to 29, 1920.

Annual meeting of engineers of the State Highway Department of Delaware, Wilmington, Del., November 22 to 27, 1920.

National Farmers' Exposition, Toledo, Ohio, December 2 to 10, 1920.

Annual meeting of Virginia Good Roads Association, Roanoke, Va., January 26 to 28, 1921.

ADDRESSES, LECTURES, AND PAPERS.

Extension work through the medium of conferences, lectures, and addresses was continued during the year. In accordance with the policy of the department, representatives were assigned to attend only those meetings and conferences of official bodies which were of State or Nation-wide importance. Fifty-two special authorizations were approved by the Secretary's office for the detail of representatives of the bureau to attend such special meetings, and in 35 cases the authorization carried permission to deliver addresses.

PHOTOGRAPHIC WORK.

The work of the photographic laboratory was much heavier than last year for several reasons. The number of photographs of Federal-aid roads has naturally increased with the development of that work. A large number of bromide enlargements of completed Federal-aid roads were made for display with the department exhibits in order to give the public an opportunity to follow the extension of the work and to show the character of the roads that are being built in the various States. A third reason for the increased work is the policy of employing the photographic process as the means of reproducing statistical tables of Federal-aid progress.

The number of negatives developed this year was 4,262 as compared with 3,488 last year.

The number of prints made increased from 19,410, the last year's record, to 27,100 this year, and, in addition, 591 lantern slides, 509 bromide enlargements, and 4,554 photostat prints were produced.

A total of 463 lantern slides and 538 bromides were colored and 540 maps were mounted on cloth.

At the end of the year the photographic files contained 24,754 negatives, 92,791 prints, and 11,975 lantern slides.

PUBLICATIONS.

The publication of the monthly magazine, *Public Roads*, was continued during the year, and it is estimated that the 12 numbers issued were equivalent to 16 publications of average department bulletin size. In addition to its value as a medium for the publication of necessary information in regard to Federal-aid work, the magazine also provides the means for the timely publication of the results of the important tests and investigations which are being conducted by the bureau and cooperating agencies. The fact that two-thirds of the articles published during the past year have been widely reprinted in the technical and popular magazines is evidence of the general interest in the subject matter of the publication.

In addition to the magazine, 13 special bulletins were contributed to the department for publication as *Department and Farmers' Bulletins*. This number does not include the annual report of the chief of bureau, which also was published.

Other items of public information were disseminated in the form of news items and syndicate stories through the agency of the department press service.

The funds at the disposal of the bureau for printing purposes are still inadequate to meet the requirements, and a great deal of material is accumulated which can not be given to the public for this reason. On account of the limited funds available, the circulation of *Public Roads* has been reduced to 4,000 copies monthly, and it is necessary to refuse requests for it from all but persons officially connected with road construction in some capacity.

FARM-IRRIGATION INVESTIGATIONS.

At no time since the beginning of the irrigation investigations has their importance been so strongly emphasized and their proper scope so sharply outlined as during the past year. The abrupt decline of prices of agricultural products and the consequent hard-

ships of those who raise them have directed attention again and again to the need of the farmer for practical knowledge of the right use of the soil and water in carrying on the work of irrigating. Every irrigation enterprise has two essential features. The first consists in the design and construction of the works necessary to provide a water supply, and the second the proper handling of the land and the water made accessible by the engineering works.

The department has had an interest in the first of these phases, which has been expressed in the studies leading to the publication of such technical reports as, for example, the brief bulletin entitled "Spillways for Reservoirs and Canals," issued during the past year; but the second phase, combining the interests of the engineer and the farmer, has become by far the more insistent in its demands for attention. After construction of the irrigation works of a new project there remains the difficult task of securing the requisite number of industrious settlers with money enough to make a start under desert conditions. When settlers are secured there follows the still more difficult task of putting the farms on a paying basis. There are feed ditches to build, sagebrush to uproot, fields to plow and level, implements to purchase, fences and farm buildings to erect, and minor necessities without end to provide for. The department's series of practical bulletins on irrigation has sought to teach the best methods of putting a farm under irrigation and the most economical ways of distributing water to growing crops. During the year several of these publications have been revised so as to describe latest practice, and a farmers' bulletin on the border method of irrigation has been sent to the printer.

Assistance to communities in bringing about the organization of drainage districts and extension of advice as to proper means and methods of effecting the drainage continued to be one of the most important lines of work carried on by the division. A study was made by the associate chief of the utility of drainage systems for irrigated lands, and a report is in preparation. The 1920 census shows from 10 to 15 per cent of the irrigated lands of the West drained or in need of drainage, and this need is becoming more extensive rather than lessening. The division has been instrumental in encouraging the reclamation of many thousands of acres of these lands. An important study of the feasibility of drainage by means of pumping from wells has been finished and a report prepared for publication.

Routine hydraulic experiments have been continued, these including tests at the Fort Collins (Colo.) laboratory of various measuring devices used in irrigation, including the venturi flume and a new current meter—both devised by members of the division—evaporation experiments, and similar studies. A technical report on the flow of water in concrete pipes was published as Department Bulletin No. 852. Field studies seeking solution of the problem of silt control were brought to practical conclusion, and preparation of a report on the subject was begun. Irrigation in the Imperial Valley, Calif., is by the water of Colorado River, which is heavily impregnated with silt. The necessity of removing this silt from the canals has severely handicapped the operation of the extensive systems of the valley. Studies of these more or less local problems have been combined with other investigations of canal-cleaning methods having application to irrigation canals generally.

A field investigation to determine seepage losses from typical irrigation canals and methods of recovering such losses was concluded. This study was made in the valley of South Platte River, Colo., one of the most highly developed irrigated sections of the West and one in which water is of great value. The losses from the canals were ascertained and carefully traced throughout the season of 1920. Preparation of a report is under way.

A map showing areas irrigated and susceptible of irrigation in California was finished and is now being lithographed for public distribution.

FARM-DRAINAGE INVESTIGATIONS.

Continuing the work of previous years, the bureau has been engaged in studying some of the general engineering problems upon the solution of which depends the economy of specific land-drainage projects.

The exact quantity of water a tile drain or drainage ditch may be called upon to handle may seem to the layman to be an unimportant matter. As a matter of fact, lack of scientific knowledge of their capacity is one of the most frequent causes of the failure of land-drainage undertakings. Overestimation of the capacity required results in unnecessary expense; lack of needed capacity involves the loss of a part of the benefit which should have come from the expenditure. The factors that determine the rate of run-off from a watershed are so diverse and so interrelated that a general run-off formula probably never can be evolved. Actual run-off from definite watersheds can be measured, however, and data thus gradually accumulated which, when considered in connection with all the governing conditions, can be applied with considerable confidence to proposed drainage channels. Similarly, the flow in open channels and underground drains can be measured with sufficient precision to establish coefficients which enable the drainage engineer to forecast quite accurately the quantity of water a drain of given size and slope will carry. It is not difficult to express the value of such research in dollars. Let one but consider the thousands of miles of large drain tile that will be laid in the next few years and then reflect that the difference in cost as between, say, 24 and 30 inch tile in place is approximately \$5,000 per mile. During the last fiscal year investigations of run-off and drain capacities were carried on in Minnesota, Mississippi, and North Carolina. The results will be made available to drainage engineers.

Another line of research carried on—principally in North Carolina—was the study of the effect of tile drainage on different soils. On selected tile-drainage systems the actual fluctuation of the ground water is recorded by observing its level in numerous small wells. Similar observations made on adjacent undrained soils give a basis for determining the proper depth and spacing of drains in such soils. At the present time guesswork largely governs these important matters and must continue to do so until similar studies have been made on all of our important soil types. The unnecessarily close spacing of drains means many dollars per acre wasted, while too great a spacing means partial or complete failure to drain.

With the increasing use of large artificial channels as drainage outlets there has come the problem of the loss of efficiency of such chan-

nels due to silting. This silt is brought down in suspension in the waters of the tributary channels which have considerable fall. On reaching the main outlet the silt is deposited, owing to reduced velocity of flow. This problem has become so serious as to merit careful study. The real sources of this silt are, of course, the hillsides of the areas drained, and it may be said that here is where preventive measures should be applied. Terracing of land, however, is as yet considered to be an individual problem, and it probably will be a long time before material relief from silting can be expected from this source. In the meantime the most practical remedy appears to be the construction of silting or sedimentation basins where the tributaries emerge from the hills onto the bottom land adjoining the main outlet. Owing to a reduction in velocity of flow as the silt-laden water reaches such a basin, the sediment is deposited before reaching the main outlet. The best locations and forms of such basins, as well as the rate of deposition of silt, are at present matters of conjecture, and there is a large field for valuable work in these respects. The bureau has undertaken a study of a number of such basins in Illinois, Missouri, and Nebraska and is making periodic measurements to determine their efficiency and rate of filling, with a view to making important recommendations.

The durability of concrete tile when laid in soils containing certain alkalies and acids has for several years been a matter of concern. In 1919 the attention of the bureau was called to a number of drain failures in southwestern Minnesota. A systematic study of the question was begun in the same year and has since been carried on continuously. Some 23 counties of southwestern Minnesota were examined in detail, tile failures located, and samples of drain water and soil water analyzed. A marked relation was found to exist between these failures and the alkali concentrations. To such an extent does this relation hold that the bureau has felt justified in carrying on the work indefinitely, and to this end arrangements were made during the last fiscal year to establish and maintain a laboratory, in cooperation with the Minnesota Agricultural Experiment Station and the State department of drainage and waters. At the request of drainage district officials, tile samples are tested, soil waters examined, and reports made as to the advisability of using concrete tile in specific areas. One of the important results of the field investigations made during the last two years has been to establish quite definitely the boundaries of the general area in which the advisability of using concrete tile is questionable. Millions of dollars are invested in tile drains in Minnesota alone, and the expenditure of millions more is planned. It would be difficult to overestimate the value of any work that will result in the prevention of the destruction of drains to be hereafter constructed.

The gullying of farm land is one of the serious problems of the farmer in many parts of the country. Gullying cuts up or destroys his fields. The products of this action either cover other land or are washed into the drainage channels, whereupon the farmer is faced with the alternative of removing the deposit at heavy expense or of suffering losses from overflow due to filling of the drainage channels. During the past year an extensive field study was made of this subject, and a farmers' bulletin has been prepared which dis-

cusses the various methods of preventing gullying and of reclaiming land already gullied.

Somewhat related to the last-mentioned subject is change of channel cross section due to filling and washing. In some parts of the country drainage channels need not be excavated to the full size required; relatively small outlets can be constructed, relying upon erosion to enlarge the channel to the required size. Systematic measurements are being made on several channels in Iowa, Mississippi, and Tennessee to determine the progress of the action.

Among the minor lines of research carried on last year were the studies of the effects of tile drainage on soil temperatures on the college farm at Athens, Ga., and of the shrinkage of drained muck soils in southern Florida.

Extension may be considered as the practical application of the results of research work. With regard to swamp and overflowed land, lack of funds prevented any considerable work in the nature of surveys and preparation of plans. In several instances, however, the plans of practicing engineers were reviewed and valuable suggestions were made. A large number of preliminary examinations of proposed drainage districts were reported upon.

Extension work in farm drainage, including protection of soils from erosion by terracing, was carried on mostly under cooperative agreements with the various agricultural colleges. Under the provisions of these agreements the State agencies furnish funds or provide certain facilities for work. During the last fiscal year such agreements were operative in Alabama, Arkansas, Georgia, North Carolina, Tennessee, Wisconsin, and West Virginia. Considerable assistance in drainage and terracing was also rendered in Indiana, Ohio, South Carolina, and Vermont.

RURAL ENGINEERING INVESTIGATIONS.

The work pertaining to structures and mechanical problems of the farm was seriously handicapped by lack of funds. The projects include many and varied problems that not only affect the farmer directly but have a vital bearing on national agricultural economics, but the funds available have not permitted the inauguration of many investigations that should be undertaken. In order that the service rendered might cover as broad a field as possible projects of a continuous nature have been curtailed so as to permit of investigations along other lines of immediate importance. At no time has the division been able to do the research work that is essential to some of its undertakings.

During the last year more stress was laid upon investigations pertaining to machinery and power problems than on other phases of the work. Certain activities formerly conducted by the Office of Farm Management and Farm Economics were taken over by the division. As this was done without addition to the funds, it was necessary to sacrifice other activities. Notwithstanding the limitations imposed, the division accomplished a very creditable amount of valuable work.

The work done falls under three general heads: That done of its own initiative the results of which are for general distribution; that done for or in cooperation with other bureaus and also for general

distribution; and that done for other bureaus and which is used in furthering the scientific and experimental projects of those bureaus. During the year the division did a large amount of work falling under the last head, ranging from the tracing of simple drawings and charts or the designing of a small piece of apparatus to complete drawings and specifications for reinforced concrete structures such as the laboratory buildings erected or now under construction at Arlington Farm.

The farm buildings designed for general distribution included two general-purpose barns, a portable house, a portable poultry brooder house, three typical septic tanks, and an apple storage house. Three farmstead layouts were prepared in response to requests for assistance. The drafting force was employed during a large proportion of the time in the preparation of illustrations for publications issued or prepared during the year.

The service rendered the agricultural public is largely through individual correspondence in which the building designs and publications prepared in the division are used. Many of the problems of the farmer are made evident in this correspondence, and it is interesting to note that water supply and sewage disposal were the subjects of a great many inquiries received. In this connection it is thought that the Farmers' Bulletin on Sewage and Sewerage for the Farm Home, which was sent to the printer during the year, and that on Plumbing Systems for Farm Homes, which was begun, will prove of great value. Also of interest are the requests for assistance in developing farm streams as sources of power and light.

The investigation of the ventilation of barns was undertaken in cooperation with the committee on ventilation of the American Society of Agricultural Engineers. The work done, consisting of tests of the ventilating systems in a number of barns, was of a preliminary nature and was designed to establish the influence of certain constant and variable factors. Further investigations will consist of tests and experiments extending over considerable periods of time in each of several buildings and, it is hoped, will develop data which will enable the division to make recommendations as to the proper construction and operation of ventilating systems and the type of barn construction best suited to climatic conditions in different parts of the country.

Operating a Home Heating Plant is the subject of a Farmers' Bulletin, published during the year, which is designed to assist the farmhouse owner to install and operate his heating apparatus properly. Another bulletin relating specifically to multipipe warm-air plants was begun. Chimneys and Fireplaces, a bulletin sent to the printer, contains matter of considerable value to the home builder.

A design for a lime-sulphur cooking plant using mechanical agitation was prepared in cooperation with the Bureau of Entomology for general distribution.

By way of cooperation with the same bureau, an engineer of the division was detailed to assist in the development of apparatus for dusting cotton plants for boll weevil.

Notes pertaining to the use of alcohol as a motor fuel, gauges for measuring draft in a residence chimney and to iceless refrigerators were added to the information series used in connection with the general correspondence of the division.

An investigation of the use of motor trucks by farmers, which was inaugurated in the Office of Farm Management during the preceding fiscal year, was completed by this bureau. The objects of the investigation were to determine the extent to which farmers own and use motor trucks, and the advantages and disadvantages connected with their use and, so far as possible, to ascertain the character of the farms on which they are used and the conditions under which motor trucks can be profitably employed. This investigation proved very helpful to agricultural investigators and to manufacturers of motor trucks. It is the only comprehensive investigation of the subject ever undertaken, and made available for the first time reliable data on the cost of hauling with motor trucks under farm conditions, the sizes and types best suited to the farmer's needs, and the profitable uses which he could expect to make of motor trucks.

The increased use of gas tractors and the radical changes in conditions during the preceding year gave rise to an unprecedented need and demand for reliable and up-to-date information that would show on just what farms and under what conditions tractors could be used profitably. In cooperation with the Office of Farm Management and Farm Economics, and with the Bureau of Animal Industry, about 300 farms in Ohio, Indiana, and Illinois on which tractors were operated were surveyed, and the results were compiled and published. A complete record was obtained of all the work on these farms, done both with tractors and with horses. Data from which the cost of operating the tractors and the cost of keeping the horses could be determined were secured, and general information concerning changes in organization and farm practices after the advent of the tractor were secured from each farmer visited. This was the first effort on the part of any agency to make a comprehensive study of the power problem on a large number of farms, and the investigation made available for the first time basic data which could be depended upon in determining the extent to which the use of a tractor will change the cost of operating a corn-belt farm, and the extent to which the tractor makes possible changes in the organization and the operation of farms in that section.

There has been much speculation on the part of everyone interested in the use of mechanical power as to the extent to which early tractor owners continue to use these machines. No reliable data were available which showed the extent to which men who purchased tractors prior to 1917 continued to use them during the prosperous period of the war and during the unprosperous year following. In order to obtain definite information on this and other related points, tractor owners in the corn belt and the Great Plains areas who purchased tractors prior to 1917 and who during that year furnished to the department reports of their experience with them were asked for a report covering their use up to the beginning of 1921. The replies from over 1,200 farmers were compared with their early reports, the comparisons were summarized, and the results made public. The investigation showed that four-fifths of these men were still using their first machines or others which they had purchased after the time of their first reports.

Tractors did not come into general use in the Southeastern States as early as in other sections, but during the past two or three years a large number of farmers in these States have purchased them. No

information has been available as to the success owners in these States are having with their machines, and we have had very little basis for giving advice or for making suggestions concerning the use of mechanical power there. During the year the names and addresses of several thousand tractor owners in Tennessee, North Carolina, South Carolina, Georgia, Alabama, Mississippi, and Florida were obtained through the township crop reporters of the Bureau of Crop Estimates, and each one of them was asked for a report of the work which he does with his tractor; the cost of operating it, his opinion as to its profitableness, and other related information. Replies from about 2,000 of these men were received, and these replies were being studied and analyzed at the close of the year.

One of the basic needs of all investigations of the use of machinery and power has been definite information concerning the extent to which machines of different kinds and sizes are used by farmers in this country. Farm equipment manufacturers have also long felt the need of reliable data of this kind. Nothing has been available except the data collected by this department concerning the number of tractors manufactured and sold during the recent years and the reports of the Bureau of the Census on the manufacture of agricultural implements. To supply the needed information, this division, in cooperation with the National Implement and Vehicle Association, collected, compiled, and made public detailed figures showing the number and value of tractors, implements, vehicles, and other farm-operating equipment manufactured and sold in the United States and abroad during 1920. Detailed reports were obtained from 583 manufacturers, and it is believed that they represent at least 99 per cent of the industry. Through the cooperation of the manufacturers, it was possible to obtain all of this information by mail and at a very low cost as compared to similar investigations conducted by other agencies. While the investigation does not show exactly the extent to which different items of equipment are used by farmers, it does show quite clearly the relative use being made of different classes and sizes of equipment, and if similar investigations can be made in ensuing years, they will form a very valuable record concerning trends and tendencies in the purchase and use of equipment by farmers.

In addition to these major investigations, all requests for advice and assistance concerning the use of farm machinery and power received by the department were handled in this division, and the preparation of a number of bulletins based on these and former investigations was begun.

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EXPERIMENT STATION FILE

REPORT OF THE DIRECTOR OF THE STATES RELATIONS SERVICE.

UNITED STATES DEPARTMENT OF AGRICULTURE,
STATES RELATIONS SERVICE,
Washington, D. C., September 28, 1921.

SIR: I have the honor to present herewith the report of the States Relations Service for the fiscal year ended June 30, 1921.

Respectfully,

A. C. TRUE, *Director.*

Hon. HENRY C. WALLACE,
Secretary of Agriculture.

INTRODUCTION AND SUMMARY.

FUNDS ADMINISTERED.

During the year ending June 30, 1921, Congress continued the appropriation of \$1,500,000 to the department to be expended under the terms of the extension act of May 8, 1914, and the appropriation for farmers' cooperative demonstration work amounting to \$1,350,520 for administration by the States Relations Service. Other funds appropriated for the work of the service aggregated \$579,640. In addition, Federal funds amounting to \$1,440,000 were appropriated for the agricultural experiment stations and \$3,580,000 for cooperative-extension work. State funds amounting to \$4,600,000 were used as an offset to the Federal funds for extension work as required by law. This service, therefore, had administrative and advisory relations in the expenditure of \$13,225,160, of which \$8,625,160 were Federal funds. In addition the agricultural colleges and experiment stations used in experimental and extension enterprises \$9,500,000, derived from sources within the States.

PERSONNEL.

During the fiscal year 1920-21 the force carried on the rolls of the States Relations Service was approximately 4,000. The number of counties having county agricultural agents was 2,050. The number having home-demonstration agents decreased from 785 to 700. This reduction was due in part to the financial distresses in certain agricultural regions. The total force employed at the Washington offices continued at 290 persons.

WORK IN AID OF THE STATE EXPERIMENT STATIONS.

Special efforts have been made to assist the State experiment stations in conserving their funds and devoting them more strictly

to definite experimental work. This has been necessary, because owing largely to war conditions there had been a growing tendency to emphasize the more superficial phases of station work and to use too much of the time of experts needed for research in teaching, extension work, or regulatory work. Relatively the stations have been at a disadvantage in many of the institutions with which they are connected because of lack of funds available for substantial experimental work. Considerable of the money appropriated by State legislatures to experiment stations has under State laws and college regulations been used for purposes involving little or no experimentation. The Office of Experiment Stations has aided in clearing up this situation, and the legislatures in a number of States have recently made increased appropriations for experimental work.

To promote better coordination of the research work of the department and the stations and to prevent unnecessary duplication a comprehensive list of station projects in operation throughout the country has been prepared and issued.

The Experiment Station Record has been regularly issued, the volumes for the past year containing nearly 7,000 abstracts of the world's literature of agricultural science, now materially increased by the resumption of the publication of agricultural research in Europe.

The number of stations receiving Federal funds is 50, including stations in New York and Connecticut not connected with agricultural colleges. In 1920 there were 1,968 persons regularly employed by these stations. Their funds aggregated \$7,674,671.39, derived from the following sources: Hatch Act, \$720,000; Adams Act, \$720,000; State appropriations, \$3,593,099.86; sales of products, inspection fees, and miscellaneous, \$2,641,471.86.

EXPERIMENT STATIONS IN ALASKA AND THE INSULAR POSSESSIONS.

Experimental work was continued in Alaska in 1920 at the stations at Sitka, Rampart, Fairbanks, Kodiak, and Matanuska. The climatic conditions in 1920 showed the importance of the plant-breeding work of the stations. At the Rampart station the varieties of wheat developed from Siberian stock and most of the barley hybrids and oat selections ripened, while their parent plants did not fully mature. Seed again tested at the Rampart and Fairbanks stations showed a higher germination of the hybrids. In the Tanana Valley farmers produced 3,000 bushels of wheat, 2,000 bushels of oats, and nearly 1,000 bushels of barley. At the Matanuska station one field of wheat yielded 40 bushels per acre. At the Sitka station good progress is being made in strawberry and potato breeding. An experiment at the Kodiak station has demonstrated that tuberculosis may be eradicated from a herd of cattle under Alaskan conditions, while at the same time healthy calves are being produced by the herd.

The Hawaii station at Honolulu, Oahu, with substations on other islands, is continuing efforts to increase the number of profitable agricultural industries and especially to make these islands self-supporting as regards food production. Special attention is being given to problems involved in the production, utilization, and preservation of such products as bananas, rice, taro, starch, fruits, nuts, etc. With

the aid of the station new areas are being brought under cultivation, and the advice and assistance of the station is sought on many problems. Extension work is being vigorously conducted on the different islands, a number of extension centers having been established among different races of people with great success. Considerable attention is being given to live stock. Poultry production has been greatly stimulated. A home-demonstration agent has been employed.

With the fall in the price of sugar, there is much greater interest in the efforts of the Porto Rico station, located at Mayaguez, to promote diversification of agriculture in that island. Seed of sunn hemp, a leguminous plant found to be well suited to rotation with sugar cane, as well as for a cover crop for citrus and coffee plantings, is being widely distributed by the station. Important results have been obtained in investigations on the effect of fertilizers on rice production. Studies of the cattle tick under conditions on the island and propaganda for its eradication are giving encouraging results. The station is aiding the growing citrus-fruit industry but greatly needs funds to support the plant pathologist. The station is doing what it can to disseminate the results of its work through publications and extension work, but there is urgent need of a much more comprehensive system of extension work by local agents among the large and for the most part uneducated agricultural population of the island.

At the Guam station much attention is being given to forage-crop investigations as a basis for increased live-stock production. A number of introduced grasses are being successfully grown and some new introductions are giving promising results. Experiments with copra meal as part of the ration of horses, cattle, and swine have given satisfactory results. The work of grading up the live stock of the island is being continued and is attracting much attention. Rice culture is being promoted by variety tests, fertilizer experiments, use of leguminous plants for green manuring and cover crops, etc. Experiments with vegetables and distribution of seeds have resulted in greatly increased planting of such crops. Remarkable success has been obtained in extension work through boys' and girls' clubs for the growing of corn, beans, roots, vegetables, pigs, and poultry. The station is aiding in the work in gardening required in the schools and in the promotion of the Government's efforts to induce the people to use improved agricultural implements. These efforts are meeting with encouraging success. The decrease in the station funds, however, has resulted in the resignation of the agronomist and extension agent, which seriously handicaps the station. It can not be efficiently conducted with its present income.

The Virgin Islands station located on the island of St. Croix, is broadening its work with vegetables and fruits essential to the diet of the people, but which at present are very largely imported. The valuable forage plant, known as elephant grass, has given such good results experimentally that cuttings are now being extensively distributed in the islands. The entomologist is continuing the survey of the insect fauna of the islands with a view to determining methods for the control of those of economic importance. The pink bollworm of cotton was reported in St. Croix in 1921 and the station is endeavoring to secure the adoption of means for its control. Extension

work has been begun and will be vigorously prosecuted, as far as means will allow, in order that the people on all the islands may be able to take advantage of the results of the station's work and become acquainted with improved methods of agriculture and horticulture.

COOPERATIVE AGRICULTURAL EXTENSION WORK.

During the year covered by this report the business of the States Relations Service relating to extension work was conducted through two extension offices, one for 15 Southern States and the other for 33 Northern and Western States. Beginning with October, 1921, these offices have been combined.

IN THE SOUTHERN STATES.

In the Southern States there were cooperatively employed 861 white county agricultural agents and 154 Negro agents. They reported 230,819 field demonstrations with crops by adult farmers and boys on 2,274,554 acres. The average yield on the demonstration fields was from 50 to 100 per cent greater than the average yields of general crops in the same territory. As the result of the agents' influence and advice, farmers purchased 69,877 head of purebred stock and 41,393 head of grade stock; conducted over 25,000 feeding demonstrations; started over 9,000 new herds; and treated over 3,000,000 head of live stock for diseases and pests.

Depressed economic conditions compelled the agents to give an unusual amount of time to marketing problems and particularly the organization of cooperative associations for buying and selling. They reported 2,031 such associations in the South, which did business amounting to \$59,678,488, with an estimated saving to farmers of \$6,544,021. Drainage, terracing, improvement of buildings and grounds, planting of vegetable gardens and home orchards, etc., also received attention. About 114,000 boys conducted demonstrations in the growing of crops and purebred animals, valued at over \$4,000,000. Bankers and business men loaned the boys over \$500,000 for the purchase of their foundation stock. Community organization of these clubs for growing and standardizing better products and improving home and community conditions was stressed during the past year.

The home-demonstration work with girls and women in the South centered around the improving of diet and other home conditions, raising and marketing of products to increase the family income, and making the home more healthful and attractive. About 240,000 members of demonstration clubs cured over 14,000,000 pounds of meat products, canned 228,500 cans of meat and over 14,500,000 quarts of vegetables and fruits, made millions of jars of jelly and other preserves, and a large amount of dried and brined products. Poultry and eggs valued at \$2,500,000 were produced and over 3,000 family cows were placed on farms. Standardization of surplus products for market was stressed. Over 100 curb markets and exchanges, doing an annual business of \$1,000,000, were established. About 2,000 new homes were built and 4,500 remodeled according to home-demonstration plans. Thousands of labor-saving devices and heating, lighting, and water systems were installed in farm homes and many home

grounds were improved with lawns, trees, and shrubbery. Home-demonstration agents were employed in 474 counties in the 15 Southern States.

IN THE NORTHERN AND WESTERN STATES.

In the Northern and Western States 1,213 counties had agricultural agents on June 30, 1921, an increase of 68 counties during the year and the highest number since the work began in that territory 10 years ago. There has been a marked increase of community organization and activity in extension work. Special stress has been laid on the formulation of definite programs of work through the joint action of the farming people and the extension agents. Last year there were 11,561 community committees aiding in the work, under whose auspices 31,914 meetings were held attended by 1,214,551 persons. Each agent conducted an average of 47 demonstrations, which in the aggregate covered a wide range of problems connected with crop and live-stock production. Largely increased attention was given to marketing problems and the formation of cooperative associations. The associations formed under the influence of county agents during six years did business amounting to over \$375,000,000 in 1920, with saving to the farmers of over \$21,000,000.

Home-demonstration agents were employed in 239 counties, and their work was aided by 49 State leaders and assistants and 78 specialists, who carried on work to a considerable extent in counties without women agents. The number of rural women acting as local leaders was greatly increased. Home-demonstration projects were conducted in 17,399 local groups and over 1,330,000 people were reached. Large numbers of women joined the farm organizations cooperating with the extension forces. Much attention was given to problems of food and diet for adults and children and to sanitary conditions on the farm and in the home. Economy of time, effort, expense, and materials in making and repairing clothing was stressed. Special efforts were made to lighten the burdens of home management by securing the installation of water systems in the farm houses, remodeling kitchens, procuring more labor-saving devices, keeping household accounts, and encouraging the cooperative purchase of household supplies. Poultry and egg production and selling has been the farm industry especially promoted by the home-demonstration agents. These agents, together with the farm women, have taken increased interest in community programs of work. It is felt that considerable progress has been made in laying a good foundation for the much wider development of the extension work for and with the farm women as soon as economic conditions improve.

The boys' and girls' club work was conducted by 185 county-club agents together with 85 State club leaders and assistants, who did much work throughout the 33 States, including many counties without club leaders. The county agricultural agents and home-demonstration agents also did a large amount of club work. The total enrollment was 216,479. The value of products resulting from club work was over \$4,620,000. Nearly \$900,000 was loaned to club members by the banks, all of which was repaid. The agricultural colleges offered 730 scholarships and conducted short courses for 3,383 boys and girls. In 1920 over 1,800 former club members were enrolled in the four-year courses in agriculture or home economics at various

agricultural colleges. Much wholesome recreation was enjoyed in connection with club meetings, fairs, camps, and picnics. In these and other ways the clubs are stimulating interest in good agriculture and country life among young people in all the States.

Twenty-seven States carried on farm-management demonstrations last year. Farm accounting formed an important part of this work and on request more than 200,000 simple farm-account books were distributed. This year 860 farm-accounting schools were held with an attendance of 19,744. Over 1,000 general farm-management meetings were held with an attendance of 53,978.

EXTENSION SPECIALISTS.

The extension specialists in the various branches of agriculture and home economics made considerable progress in defining and systematizing their work and coordinating it with the work of the county agents, both men and women. They have taken a large share in the determination of the county programs and have become to a greater extent useful intermediaries between the people and agents in the counties and the experiment stations and department bureaus. They are also making their work more permanent and showing its real significance by improving their records and reports.

INVESTIGATIONS IN HOME ECONOMICS.

The Office of Home Economics somewhat increased its experimental work. This related chiefly to problems of relative food value and selection, meal planning, food requirements of children, special studies of cooking and canning processes, and of the relative efficiency of different fuels in food preparation. Some studies were also made on the selection, repair, and care of clothing and household equipment and considerable information on these subjects was gathered from various sources and disseminated to housekeepers, extension workers, and others.

In the experimental kitchen studies in pastry making included experiments with reference to effects of different methods of handling and mixing the dough, temperatures as related to various ingredients of the dough, use of pans of different materials, etc. Such work has shown, for example, that the recipe used, the method of mixing and handling the dough, and the baking temperature affect the quality of the crust more than does the kind of fat. Bacterial studies in home canning have been made, the use of acid in canning vegetables, heat penetration as related to closeness of packing, and other factors being considered. It has been shown that the pressure cooker may be advantageously used for cooking vegetables, meats, and other foods. Useful results were obtained from studies of methods of extracting fruit juices for jelly making. Fundamental studies regarding the relation of cooking to vitamines were undertaken.

Laboratory studies on the digestibility of various foods, including raw starches, were reported. Studies of energy expenditure in household tasks were continued with the aid of the respiration calorimeter, including especially last year the energy requirements of sewing on different materials and with power machines or by hand.

Calorimeter studies on heat production and oxidation in ripening fruit and on artificial incubation of eggs were continued.

A large amount of practical information was disseminated through farmers' Bulletins, articles in the Weekly News Letter, and mimeographed material sent to extension workers. Reports of experimental work were published frequently in technical and professional journals.

AID TO FARMERS' INSTITUTES AND AGRICULTURAL SCHOOLS.

Closely related to the extension work of the States Relations Service have been its efforts to aid the farmers' institutes and the schools in which agriculture is or should be taught. During the past year the farmers' institutes in 15 States continued to be in charge of the State departments of agriculture, while in the 19 other States in which institutes were held they were in charge of the agricultural colleges and formed a part of their extension work. Reports from 33 States show that 10,145 institutes were held with an attendance of 2,323,674, which is nearly double the attendance of the previous year. These figures and evidence obtained by correspondence and visits to a number of States indicate that the farmers have an increased interest in these meetings, which in many respects afford them an open forum for the discussion of their own problems and bring out matters on which they desire to have the assistance of the extension forces.

The States Relations Service continued to aid the institute managers and lecturers by giving them information through publications and otherwise and loaning them lantern slides prepared in the Department of Agriculture.

The service also continued the preparation of up-to-date subject-matter on agricultural subjects in form for immediate use by teachers of agriculture in secondary and elementary schools.

In cooperation with the Federal Board for Vocational Education under the provisions of the Smith-Hughes Act unit courses of study in poultry husbandry, swine husbandry, and potato growing were prepared, incorporating a job analysis of these farm enterprises as a new feature of agricultural teaching in which the problem method is used.

In cooperation with the State departments of education and the agricultural colleges, courses in agriculture on a seasonal basis were outlined for elementary schools in Arkansas and North Carolina. Leaflets embodying suggestions to teachers regarding the use of certain Farmers' Bulletins in school work were issued.

Special efforts have been made to aid teachers of agriculture in service and in normal schools and other teacher-training agencies by personal conferences, correspondence, and distribution of publications and illustrative material. There has also been cooperation with the Association of Land-Grant Colleges in efforts to improve college teaching of agriculture.

DUTIES AND ORGANIZATION OF THE SERVICE.

In general, the States Relations Service represents the Secretary of Agriculture in his relations with the State agricultural colleges and

experiment stations under the acts of Congress granting funds to these institutions for agricultural experiment stations and cooperative extension work in agriculture and home economics, and in carrying out the provisions of the acts of Congress making appropriations to the Department of Agriculture for farmers' cooperative demonstration work; investigations relating to agricultural schools, farmers' institutes, and home economics; and the maintenance of agricultural experiment stations in Alaska, Hawaii, Porto Rico, Guam, and the Virgin Islands.

The service has included the following offices: (1) Office of the Director, which deals with the general business and administration of the service and the work relating to agricultural instruction and farmers' institutes; (2) Office of Experiment Stations, which deals with the work and expenditures of the State and Insular experiment stations; (3) Office of Extension Work in the South, which has charge of cooperative extension work in 15 Southern States; (4) Office of Extension Work in the North and West, which has charge of cooperative extension work in 33 Northern and Western States; and (5) Office of Home Economics, which deals with questions of food, clothing, and household equipment and management.

OFFICE OF THE DIRECTOR.

The general administrative business of the States Relations Service was conducted during the past year on the same general plan as heretofore. Continued efforts were made to simplify and consolidate the routine business connected with appointments, accounts, supplies, and the preparation and dissemination of publications and illustrative material. As a clearing house regarding the organization and progress of research and extension work in agriculture and home economics throughout the world, this service is called upon to furnish a large amount of information to the department bureaus, committees and Members of Congress, agricultural colleges and schools, foreign institutions and individuals, etc., through correspondence and conferences as well as publications. The review of the numerous projects and budgets submitted by the cooperating institutions, the settlement of questions regarding the expenditure of Federal funds by these institutions, and the determination of problems connected with the cooperative employment of the large and shifting extension forces in the 48 States and the growing enterprises of the insular experiment stations necessitate much business in the director's office.

EDITORIAL DIVISION.

W. H. BEAL, *Chief.*

PUBLICATIONS.—Publications printed for the States Relations Service during the year included 60 documents aggregating 3,467 pages, as follows: Twenty numbers of Experiment Station Record (including 2 index numbers), 2 administrative reports (the report of the director of the service and a report on cooperative extension work), 4 new and 5 revised Farmers' Bulletins dealing with home economics subjects, 1 department bulletin devoted to lessons in for-

estry, 12 department circulars, 6 of which dealt with different features of cooperative extension work, 5 were leaflets explaining how teachers may use various Farmers' Bulletins of the department, and 1 was a revision of an extension leaflet on peppers, 13 publications of the stations in Alaska and the insular possessions, 2 Yearbook articles, and 1 miscellaneous document (list of workers in agriculture and home economics in the land-grant institutions). Several articles relating especially to the work of the service in home economics were published in outside journals. The business connected with the job printing and binding required by the service was handled as usual. The duplicating work required by the service was done in this division.

The division cooperated as heretofore with the Press Service of the Division of Publications of the department in assembling and preparing a large amount of press material relating to the work of the service.

ILLUSTRATIONS SECTION.—The work of this section followed the same general lines as in previous years.

The section cooperated with other offices of the service in securing several carefully planned series of photographs to illustrate the work of the service in the field as well as to illustrate publications and publicity matter. There were added to the collection 1,602 prints, making the total number of photographs now in the collection 15,074, of which 12,160 are mounted, classified, and catalogued. A complete outline of the scheme of classification of photographs used by the section was prepared and a limited number of mimeographed copies distributed during the year.

In cooperation with other offices of the service and other bureaus of the department 7 sets of lantern slides were prepared, illustrating the value of birds in relation to agriculture, swine breeding, feeding and management of swine, better sires and better live stock, barberry eradication, farm slaughtering and handling of lamb and mutton, and county-agent work in the Northern and Western States.

Two lantern-slide colorists were added to the force during the year, and 3,642 lantern slides, 6 transparencies, and 44 bromide enlargements were colored.

Three hundred charts, drawings, and designs were made for service use.

The section continued to cooperate with the Office of Exhibits in the preparation of exhibit material. Direct assistance and suggestions were also given to cooperating institutions in preparing and presenting exhibits of the extension work.

Motion-picture films, entitled "Helping Negroes to Become Better Farmers and Homemakers," "The 4-H Camp for Boys and Girls," "A Matter of Form," "Lifers and Liars," "The Happier Way," and "Food for Reflection," were prepared in cooperation with the Motion-Picture Laboratory. These films deal primarily with the actual organization and results of the cooperative extension work of the service.

On request of the State-extension services, a representative of the section attended State conferences in North Dakota and Vermont and gave short talks and demonstrations in extension photography.

INVESTIGATION ON AGRICULTURAL INSTRUCTION IN SCHOOLS.

ERWIN H. SHINN, *Chief Specialist in Agricultural Education.*

The States Relations Service in its work relating to agricultural instruction in schools continued as heretofore to make studies of methods and the content of subject matter for use of teachers of agriculture in secondary and elementary schools, and to make available to these teachers and to students of agriculture things especially useful to them derived from the vast amount of agricultural information constantly being accumulated by the Department of Agriculture, the agricultural colleges, and the experiment stations.

The importance of teaching agriculture in secondary and elementary schools is being recognized as never before, and much interest is being manifested in the study of agriculture. The increase in the number of secondary schools teaching agriculture has been marked. The standard of the qualifications of agricultural teachers has been raised materially, and there is every indication that more efficient teaching is being done. Definite programs have been established in all the States for the purpose of promoting the teaching of agriculture. Teacher-training divisions have been organized and as a result teachers are being better trained for service. In connection with this new movement the demand for knowledge of the latest methods of instruction and other up-to-date information which might be helpful to teachers of agriculture has increased materially.

Through cooperation with the specialists of the different bureaus of the department, up-to-date suggestions and material are secured. With this assistance the small force of three specialists in agricultural instruction of the States Relations Service is rendering a valuable service to the cause of agricultural education not performed by any other agency.

The work is being conducted at present along the following lines: (1) Cooperation with the Federal Board for Vocational Education in the preparation of publications for use in the secondary schools, particularly those receiving the benefits of the vocational education act; (2) cooperation with the States in preparing courses of study in agriculture for elementary schools; (3) cooperation with the teacher-training forces in the States by helpful publications, conferences, correspondence, and the loan of illustrative material; and (4) cooperation with the teachers in service by furnishing information for use in their schools, by giving suggestions on the use of such material, by encouraging home-project work, and by lending lantern slides on agricultural subjects.

In cooperation with the Federal Board for Vocational Education a job analysis was made of three important farm enterprises in producing and marketing agricultural commodities. The job-analyzed farm enterprises were drafted into three unit courses of study, namely, A Unit Course in Poultry Husbandry, A Unit Course in Swine Husbandry, and A Unit Course in the Potato Enterprise. These courses were prepared for use in the vocational agricultural schools operating under the Smith-Hughes Act.

In cooperation with States in preparing courses of study in agriculture for elementary schools, the course of study prepared for the Arkansas schools was completed and turned over to the State super-

intendent of public instruction for publication. A similar course of study has been prepared for the elementary schools of North Carolina and is now in the hands of the State superintendent of public instruction of that State. Conferences were held during the year with the State superintendent of public instruction of Ohio and agricultural teachers in the normal school at Kent, Ohio, regarding the use of the State course of study in elementary agriculture prepared previously by this office for the rural schools of Ohio.

In cooperation with teacher-training divisions in States, the unit courses mentioned above have been regarded quite valuable in giving suggestions to those intrusted with the duties of training teachers of agriculture. A number of department circulars offering suggestions on how teachers may use certain Farmers' Bulletins have been prepared and distributed to teacher-training agencies. Classified lists of all department publications, together with lists of other material useful to teachers, have been widely distributed among teachers of agriculture.

In cooperation with teachers in service, it is believed that this division renders most useful service. Large numbers of teachers are supplied with those publications of the department which are best adapted to their special needs, together with suggestions on the use of such material. Information relating to sources of agricultural knowledge which might be of value to teachers is also furnished, special consideration being given to such materials as may be used to the practical advantage of the students.

Visual instruction has come to occupy a place of vital importance in the educational program. Teachers of agriculture realize the value of material of this kind. So great has been the demand that we have been unable to supply the material in adequate quantities. New sets of lantern slides, with special consideration to pedagogical arrangement were prepared during the year. The new sets of slides on birds and their relation to agriculture and the set on corn production and distribution have been in constant demand. Other sets of slides are at present in process of preparation. The distribution of lantern slides has been extensive, the slides being used in practically every State. An increased number of State circuits for the distribution of slides were also established.

This division continues to review and abstract literature on agricultural education for the Experiment Station Record.

Representatives of the office took part in annual conferences of State supervisors for vocational agricultural education and teacher-trainers for vocational agricultural teaching in the Southern and North Atlantic regions. Summer conferences of vocational agricultural teachers held at the agricultural colleges in eight States were also attended. The farm-enterprise job analysis and unit-course plan were presented at these conferences, special emphasis being placed upon how the courses should be used in the secondary schools offering vocational courses in agriculture. Conferences were held and studies made with heads of teacher-training divisions in 15 States regarding methods used for organizing material for teachers of agriculture. At these conferences information was secured as to the adaptability of certain courses of study to teachers' needs. Suggestions were received as to how this office might render more efficient service to teachers of agriculture.

Cooperation with the Association of Land-Grant Colleges was continued through its committee on instruction in agriculture, home economics, and mechanics arts, of which the director of the service is chairman. A report of the committee on the improvement of college teaching of agriculture, with special reference to the technical and professional training and the teaching and vocational experience of college teachers engaged in vocational instruction, was made to the association at its annual meeting in October, 1920, and was published in the proceedings of that meeting.

Special studies in the problems of visual instruction in agriculture looking to the preparation of illustrative material for lantern slides based upon actual project conditions where pupils are doing practical work on the farm and in the shop, are now under way. It is believed that material of this kind will be of special benefit to teachers in stimulating renewed interest in agricultural classes. Emphasis will be placed during the year on making available to teachers of agriculture illustrative material having special educational value, and also on the preparation of suggestive courses based upon the latest available information.

INVESTIGATIONS ON FARMERS' INSTITUTES.

J. M. STEDMAN, *Farmers' Institute Specialist.*

Farmers' institutes during the fiscal year ended June 30, 1921, were officially in charge of the State government in 15 States, while in the remaining States they were in charge of the extension divisions of the agricultural colleges. A total of 34 States conducted farmers' institutes during the year. The combined reports of 33 of these States show a total of 10,145 institutes which lasted 10,731 days, comprised 32,010 sessions, had an attendance of 2,323,674, employed 1,407 lecturers, and cost \$304,382.65. These figures show an increase in farmers' institutes from the preceding year of over three times the number of sessions held, nearly twice the attendance, and a 50 per cent increase in the amount of money expended for this work.

The Division of Farmers' Institutes continued to aid farmers' institute workers along the same lines as heretofore, as well as other similar groups of extension workers throughout the country.

A special study of the organization, methods, progress, and effective results of farmers' institutes was made in 10 States during the year, and conferences were held with farmers' institute directors and lecturers, and also with farmers in attendance at the meetings, with a view to strengthening this method of extension teaching.

An intensive study of the comparative effectiveness of farmers' institute and demonstration work as regards the actual benefits exerted by each on the farmers themselves and the agriculture of the region was also conducted during the year as a continuation of a study inaugurated six years ago.

The progress in agricultural extension in foreign countries was reviewed and the results were published in mimeographed form.

OFFICE OF EXPERIMENT STATIONS.

E. W. ALLEN, *Chief.*

The administrative and advisory functions of the office in relation to the State experiment stations under the Hatch and Adams Acts have continued much as in previous years. Effort has been made not only to conserve the use of these funds to the purposes for which they were appropriated, but by close contact and counsel to stimulate the work of these institutions and to strengthen their relations. The publication of Experiment Station Record, a world review of progress in agricultural investigation, has been continued as an aid to workers in keeping promptly informed on new results and methods, and the card index of American experiment station literature has been resumed. A report of the work and expenditures of the State and insular stations has been prepared.

The office has maintained a register of workers in agricultural science for the purpose of assisting the stations in recruiting their staffs and of placing those desirous of entering upon such work in contact with the station authorities. A personal visit to each of the stations has been made by a member of the office, which not only serves for a detailed examination of the work and expenditures, but gives opportunity for conference with college presidents, station directors, and staff members on matters relating to the progress of station work, its organization, administration, and needs.

PROGRESS OF THE STATE EXPERIMENT STATIONS.

The experiment stations have been passing through a critical period in their career, arising primarily from the effect of the war and the diversion of attention to other channels of effort. To recover from this will call for the most careful administrative effort and will be a matter of some time. Most of the stations have been obliged to abandon or interrupt work on certain of their projects, restricting their activities to those of outstanding importance or which would suffer most from interruption. The quality of the work has also been interfered with by the change of personnel, the inability to employ sufficient assistants, and the general financial situation.

The American stations have the finest plant to be found in any country. The operation of this plant on a part-time basis or at reduced capacity is not only equivalent to allowing machinery to stand idle that would be productive, but interrupts the proper continuity and stability of research which is essential to its success. Many investigations are planned to extend over a series of years, and if interrupted or curtailed suffer irreparably. It has required careful planning and skillful calculating to keep alive investigations of this class, and new pressing problems which have come forward have had to be largely postponed.

Happily, however, there are indications that the stations have turned the corner and are now on the road to an era of larger prosperity. The situation of many of them has been measurably improved during the year. In a considerable number of States the appropriations or allotments for their use have been increased, in a few cases as much as 50 per cent; and, in addition, the effect of the

quite generally increased scale of salaries at the colleges with which the stations are connected has materially relieved the situation with respect to the station personnel.

While the increase in funds for maintenance has not been general throughout the country, it has extended to many of the larger and more prominent stations. It has enabled them to expand their activities somewhat, to reopen projects which had been inactive, to secure needed equipment hitherto prohibited by lack of means, and, perhaps most important of all, it has shown that these research institutions are not to be left out of the plans for agricultural advancement.

In the case of most institutions the increased appropriations did not become available until near the close of the fiscal year or even later, but they gave a basis for planning on a larger and more effective scale, and they afforded encouragement for the future of these institutions. The comparative ease with which they were secured in a number of cases pointed to the readiness to support this research branch at the present time.

A general revision of the salary scale was found to be inevitable by nearly all the colleges, deficits being authorized for that purpose in a number of cases. The station employees shared in the benefits of this higher scale, which likewise gave stimulus to persons to enter and remain in the research field. The loss of workers has been checked and a larger supply of recruits is now available. Prospectively the stations as a group may be said to be in better condition than they have been for several years, with an enlarged opportunity for a revival of their former activity and encouraging outlook for the future.

In the supervision of the Federal funds emphasis has been laid on holding these funds as far as practicable to definite experimental work, instead of using them for general maintenance and incidental purposes. This brings out the necessity for State appropriations or allotments definitely assigned to the station. To that end it has been urged that the stations be recognized in the legislative budget, setting forth their needs and calling public attention to the importance of their adequate support. In a considerable number of cases this has not been the practice. In such cases the station has not been definitely mentioned in the college budget and the allotment to it is made from the general funds of the institution. This has often placed the station at a disadvantage, and aside from increasing the difficulty in planning for growth it has cut it off from contact with the public in the expression of its needs and in presenting the importance of its activities. The response during the past year where specific appropriations have been asked in the name of the station has indicated the advantage of such a procedure.

One respect in which the stations have yet to recover is in the provision for adequate administrative attention. Beyond question this is in considerable measure associated with their general welfare, with the position they occupy, and with the extent to which they are effectively meeting the need for research. In a considerable number of cases administrative officers are so burdened with other engrossing duties that there is a conspicuous lack of close attention and study

of the work of the stations with respect to the most effective program, adequate planning of projects, and the evidences or promise of substantial progress on lines under way. There is large opportunity for a type of administration which will be stimulating without weakening initiative, will supervise without dictating detail, will guide without assuming technical control, and will exercise where necessary that wise discrimination and authority which a productive and properly related program requires. Objection to close organization and effective administration is largely theoretical. Fear of it comes less frequently from the class of productive workers concerned for the advancement of research for the benefit of agriculture than from those who are concerned with the preservation of their individual academic freedom. Less adequate provision for it has come largely as a result of growth in other directions, and is regarded as a source of weakness. It is a matter worthy of careful consideration in restoring the stations to their former position and prestige.

During the year the directorship of no less than eight stations changed hands. In several of the cases some of the oldest directors in point of service were involved. Two of them had occupied such positions from the establishment of the stations under the Hatch Act, and others for from 15 to nearly 25 years. Such changes are to some extent inevitable, but when they result from political or other unfavorable conditions, they show that the stability of these high positions is not yet fully assured.

EXPERIMENT-STATION PROJECTS.

For the first time in the history of experiment-station work a list has been compiled of the various projects carried out at the different stations. There has been much call for such a list, and with the cooperation of the stations the projects were assembled and the list issued in mimeographed form during the year. It included some 3,750 projects, aside from those relating to administrative and regulatory functions. The titles were classified by subjects, and subdivided so as to bring together investigations of similar nature. Numerous cross references were also inserted to facilitate ready reference. A card index of these projects has been completed, and changes are entered to keep it up to date.

One result of the publication of such a project list should be to enable a closer contact between workers on similar or related topics. By showing what phases of such topics are being investigated and by whom, communication among those having common interests is facilitated. In this way cooperation will be made more practicable, and there may be at least common understanding amongst investigators in the same field. Such a list will also remove the excuse for duplication or repetition of a kind which is unnecessary. Where repetition is required it can be conducted with more definite reference to the work of others and to the point which has been reached in experimentation. Inferentially the publication of such a list shows not only where stress is now being laid, but directions in which investigation is relatively weak or deficient. There are some subjects on which relatively little original research is yet in progress, and this fact is an indication of the need for growth. The list is therefore

not alone a catalogue of what is under way, but an evidence of what needs to be done to strengthen the research efforts of the American stations.

EXPERIMENT STATION RECORD.

The program for the year included the publication of volumes 43 and 44 of Experiment Station Record, each consisting of nine numbers and the usual author and subject indexes. These volumes contain 6,971 abstracts of the world's scientific literature pertaining to agriculture, together with the usual monthly editorials discussing important phases of developments in agricultural investigation and brief notes on the progress of institutions for agricultural education and research in this country and abroad. The total number of articles abstracted was slightly smaller and the space per abstract slightly greater than for the previous year.

There was no change of policy as to the scope and treatment of material. The amount to be examined, however, was unusually large. The experiment stations in particular issued many publications which had been delayed during the war. There was also a notable influx of publications from Europe. These conditions increased the difficulties due to space limitations and intensified the problem of careful selection of material.

CARD INDEX OF STATION LITERATURE.

In response to many requests for the continuance of the Card Index of Experiment Station Literature, several hundred cards were issued and distributed during the year. Shortage of expert assistance has thus far greatly retarded the preparation of this index, but it is hoped that arrangements may soon be made for bringing it to a current basis and the issuing of cards thereafter quite promptly.

DIVISION OF INSULAR STATIONS.

WALTER H. EVANS, *Chief.*

The Division of Insular Stations continues to represent this department in the administration of the Federal Agricultural Experiment Stations in Alaska, Hawaii, Porto Rico, Guam, and the Virgin Islands. The accounts of these stations were also reviewed in the bureau accounting office.

During the past year the stations continued their efforts to return to the status of the prewar period. Changes in the staff of some of the stations have resulted in a partial readjustment of the work. Quite a number of projects have been suspended and only a few new ones have been taken up. New groupings of lines of work have taken place and, in general, the investigations now pursued are those which appear to be the most urgent in the development of the policies adopted for the stations. No change in policies has been effected. All the stations continue to work for the diversification of the agriculture in their respective localities. With the reduction in lines of work and every economy that can be safely practiced, the stations are finding it increasingly difficult to maintain themselves on their present incomes. The earlier pioneering work of the stations has

developed many problems that should be taken up and solved. Some of these are of a fundamental nature but their proper investigation is impossible with the resources at hand. The entire resources of the stations are the annual appropriations made by Congress, which were in 1921: Alaska, \$75,000; Hawaii, \$50,000; Porto Rico, \$50,000; Guam, \$15,000; and Virgin Islands, \$20,000. These sums have not been increased for several years, and in the case of the Guam station there is a decrease. The stations deposited in the United States Treasury as miscellaneous receipts derived from the sale of products for 1921, \$5,153.71. This sum is not available to the stations for their support.

Almost without exception the stations require for their efficient work more trained men, additional equipment, and buildings. The Alaska stations have the results of about 20 years' work that should be taken to the settlers and explained by an extension agent. For efficient service additional buildings are needed to replace log structures that are falling in decay. Additional live stock is required if the breeding experiments for the production of hardy races of animals are to give results within a reasonable time. In Hawaii the station is not utilizing its equipment in plant pathology or entomology through a lack of funds, and its opportunity for extension work in homes is not being met for the same reason. The Porto Rico station has laboratory equipment for a plant pathologist but no one to carry on the work. The work in agronomy and extension in Guam has been all but suspended, and the herds and flocks reduced, as they could no longer be maintained on the station's income. The continued inability to take up important investigations is causing criticism of the stations by those seeking their assistance. Alaska, Guam, and the Virgin Islands are not in position to materially assist the stations, and the insular station in Porto Rico and the private experiment station in Honolulu have incomes far in excess of the Federal stations, and as a result they have been able to increase their staff and take on new lines of work. This is gaining prestige for the local stations and invokes comparisons not at all favorable to the Federal stations. All these conditions can not fail to have an influence on the morale of the station men who feel their isolation and the limitations placed on their work.

ALASKA STATIONS.

At the end of the fiscal year M. D. Snodgrass, who had been superintendent of the Kodiak station for 10 years and of the Fairbanks station for 4 years, resigned. He was succeeded at the Fairbanks station by G. W. Gasser, who had been in charge of the Rampart station since 1908. C. S. Hahn, assistant at the Fairbanks station, was transferred to Rampart and took up work at that place in April.

The season of 1921 is reported as exceptionally favorable for agricultural operations, and the outlook for field and garden crops was very promising at the end of the fiscal year. The Milking Short-horn cattle and other stock purchased for the Fairbanks and Matanuska stations in the summer of 1920 came through the winter in good condition. The Galloway cattle at Kodiak wintered well, as did the Holsteins that had been secured for the experiment in establishing

a cross with the Galloway that should combine, if possible, the hardiness of the Galloway with the milking qualities of the Holstein. Ten calves have already been produced, only four of which are heifers. One of these freshened the past spring, but she is a very poor type of animal and shows no improvement in milk production over the Galloways. All the calves have been polled, and the black color has been entirely dominant. The herd at Kodiak was again tested for tuberculosis, and no reactors were found. The reactors that have been isolated at Kalsin Bay were slaughtered prior to the test, and the herd is now believed to be sound. Before they were slaughtered this quarantined herd produced 11 calves, which were reared on pasteurized milk. None of these calves have reacted to the tuberculin test, although repeatedly tested. This experiment has demonstrated the possibility of the eradication of tuberculosis from a herd of cattle under Alaskan conditions, while at the same time the herd is being increased. Its successful termination was very timely, as, in cooperation with Territorial officials, the veterinarian tested over 600 cows in a number of localities and found at least 25 per cent reacted. Where there were no clinical symptoms of disease, aside from the reaction to a tuberculin test, these cows could have been used to raise healthy calves by following the method adopted by the station. On account of the slight local demand for Galloway cattle the herd at Kodiak will be reduced, as the cost of keeping so large a number is rapidly exceeding the income of the station. A few of the best animals will be retained for further breeding experiments.

The summer of 1920 was characterized by low temperatures and much cloudy weather and as a result not all varieties of grain matured in the interior valleys. At the Rampart station the varieties of wheat developed from Siberian stock and most of the barley hybrids and oat selections ripened, while their parent plants did not fully mature, although many of them had been grown at the station for several years. Somewhat better results were obtained at the Fairbanks station and practically all the early seedlings matured. Early in 1921 tests were made of grain intended for seeding at the Rampart and Fairbanks stations, and the germination of the hybrids was higher in every case than the parent varieties. This seems to indicate increased earliness and better maturity on the part of the hybrids when harvested. In the Tanana Valley, in 1920, there was produced 3,000 bushels of wheat, 2,000 of oats, and nearly 1,000 of barley. A cooperative mill of 25-barrel capacity has been erected at Fairbanks to grind the grain produced in the vicinity.

At the Matanuska station there was a frost-free period of 138 days in 1920, yet much of the grain on rich land failed to ripen. That sown on less fertile bench land matured its crop. One field of wheat at the station yielded at the rate of 40 bushels per acre. At least 1,000 bushels of grain were produced in the region contiguous to the station and a large amount of hay was secured from grain that did not mature. Root crops did well, and it is estimated that potatoes to the value of \$28,000 were produced in the Matanuska Valley.

The strawberry-breeding work is being continued at the Sitka station, where in 1921 more than 2,000 hybrid plants were under observation. Plants of some of the hybrid strawberries produced several years ago were sent to the Rampart station, located about 65 miles

south of the Arctic Circle, and they wintered successfully when covered by snow until late spring. Potato breeding is making definite progress and from a large number of seedling selections have been made that are early, of good quality, and very productive.

There is great need for extension work in Alaska, where many of the settlers have had little experience in agriculture prior to their taking up homesteads. Some work of this character was undertaken in the Tanana Valley during the war, and the success achieved led the agronomist in charge to renew his recommendation for an extension agent, who will devote all his time traveling from valley to valley instructing settlers regarding their problems. The results of 15 to 20 years' experimentation should be put in active practice through extension work in different localities, many of which are remote from the stations. All the stations require additional equipment and some are in urgent need of buildings to carry on their work in an efficient manner. It is strongly urged that means be supplied to meet the station's requirements.

HAWAII STATION.

During the past year the work of the Hawaii station was confined to projects, the solution of which, it was believed, would do most to further the diversification of the agriculture of the islands. The larger agricultural interests are well organized and equipped for the solution of their problems, but the minor industries are not so situated, and it is for these more numerous but less fortunate individuals that the station is directing its efforts. Aside from sugar and pineapples Hawaii does not supply all of its food necessities, but annually imports food products to a value of several millions of dollars. Especial attention is being given to food-producing plants, such as bananas, rice, starch-yielding plants, taro, fruits, nuts, etc., not only as to their production, but their utilization, and especially their preservation in case of temporary overproduction. New areas are being brought under cultivation, and the advice and assistance of the station is sought on many problems.

The position of horticulturist was filled at the beginning of the year and some changes were made in the investigations. Through the efforts of the station plantings of bananas, avocados, papayas, etc., are being rapidly extended and the station has in progress experiments to utilize the portions of the crops that are not marketable. Drying bananas, extracting oil from avocados and utilizing the fruit in other ways, and the extraction of papain are some of the methods of conservation that are being worked out. A considerable planting of grapes, including the varieties used for Zante currants, has been made to test their adaptability to Hawaiian conditions. Renewed efforts are being made to bring together and test the value of native varieties of bananas, some of which are becoming very scarce. After a number of years of experimenting with citrus fruits, the station is now concentrating its efforts to bring about more extensive plantings of Polynesian oranges, commonly known as Kona oranges, Kusai limes, sweet shaddock, and Eureka lemons. Extended trials have shown the value of these fruits and they are being propagated for distribution as rapidly as possible. The effort to produce a tomato resistant to the fruit fly has been continued, and a round fruited type

has been secured that approaches in size and quality the Earliana, which is one of the parents. The demand for seeds and plants of this hybrid tomato exceeds the station's supply. It is not considered a function of the station to supply seeds and plants that can be secured through commercial channels, but surplus stocks of introductions are distributed on request. This encourages wide dissemination of tested varieties and enables the station to secure data on their behavior under varied conditions.

In the agronomy division the work with root crops, especially cassava, taro, sweet potatoes, and edible canna, is progressing satisfactorily. The efforts to produce a yellow strain of Guam corn have been successful and several acres has been planted to such a strain that gives promise of being productive, resistant to leaf hoppers, and adapted to cultivation at low elevations. The introduction and trial of new forage plants are being continued, and as a result of their excellent showing many calls have been made on the station to supply cuttings of Napier and Merker grasses and Uba cane to plant as soil-ing crops. In cooperation with the chemist, experiments are in progress to determine the proper stage of growth for the harvesting of the edible canna.

The chemical division is continuing the long-time fertilizer experiments with pineapples, bananas, and upland sugar cane, as well as rotation experiments in which a number of crops are included. The experiments on the control of pineapple wilt by the application of various chemicals to the roots and tops of the plants have been terminated. Small increases in the weight of the fruit and decreases in the number of second-grade fruits were found for some of the treatments, but the wilt was in nowise reduced. This experiment is being continued on a large scale by the Hawaii Pineapple Packers' Association. Samples of papain were prepared by the chemist and submitted to an eastern drug company that pronounced them superior to any on the market. A large amount of attention was given to studies of various starches and their possible commercial supplies. Particular attention was given to the starch derived from several species of tree ferns, some of which are abundant on the island of Hawaii. A small industry has been established for the manufacture of tree-fern starch but, if it is to be continued for any length of time, means must be adopted to secure continuous supplies. Little is known regarding the growth of tree ferns and experiments are in progress to determine the best methods of propagation and rate of growth. A study was also made of the residues from starch manufacture with a view of increasing starch extraction.

The extension activities of the station have been carried on with vigor on the different islands. The new demonstration farm, located among the Haleakala homesteads, has been organized and the work planned is well under way. Considerable attention has been given to extension work with live stock and increased herds and flocks are to be found throughout the islands. A great stimulus has been given poultry production through the work of the station staff and the collaborators. During the year a home-demonstration agent was employed on a part-time basis. In collaboration with various members of the station staff formulas and recipes for the utilization of many native products have been developed. Quite a number of ex-

tension centers have been organized among different races of people and the work has met with such phenomenal success that it would seem advisable to put it on a full-time basis.

PORTO RICO STATION.

Owing to the greatly reduced price of sugar, agriculture is undergoing a readjustment in Porto Rico, in common with many other countries. This has given the station an opportunity to bring some of its work to the attention of the people and to strongly urge the benefits of a greater diversification of crops and increased production of live stock and dairy products.

In order to get data on cost of production a survey was made of seven dairies, one of which was composed of high-grade Guernseys, two were mixed Holstein and Jersey grades, and four were native cows. The average milk production per cow from November to June for the grades was 11.36 pounds of milk per day and that of the native cows was 6.48 pounds. The average percentages of butter fat were 5.15 and 4.19, respectively.

With the fall in price of sugar, planters are beginning to give more attention to the rotation of their fields and the station has distributed large quantities of seed of sunn hemp, *Crotalaria juncea*, a leguminous plant that has been found to be splendidly suited to rotation with sugar cane. Sunn hemp can be sown after cane is cut for the last time and the crops turned under within three months and cane again planted. Yields of more than 12.5 tons of sunn hemp have been secured within 10 weeks. This plant has also given excellent results as a cover crop for citrus and coffee plantings and its use is being rapidly extended.

The plant-breeding work of the station has been pursued quite actively. A considerable amount of a variety of sugar cane that is resistant to the mosaic or yellow stripe disease, has been grown and distributed by the station. Some selections have been made from the black bean introduced a few years ago from Venezuela. The original variety is very prolific and resistant to disease, but, by reason of the color, the beans are not in demand for food. Light-colored mutations have been found that equal the original variety in all respects, and an effort is being made to establish and introduce them into general cultivation. Several strains of corn that are high yielding have been produced and they are being given a thorough trial at the station in cooperation with a number of planters. The breeding work, begun several years ago with tomatoes, has given some definite results. Crosses made with the so-called native tomato have given offspring, some of which are of good quality and nearly or quite immune to wilt. In culture work with tomatoes, it has been found that by cutting back the vines frequently a large second crop can be secured. As a result of the station's work it is now possible to obtain tomatoes of good quality at almost any time of the year, where formerly only the small, wrinkled, native fruit, suited only for flavoring purposes, was available.

Considerable attention has been given to root crops, and during the year trials were made of many varieties of yams, sweet potatoes, yautias, etc. In a test of 34 varieties of sweet potatoes the variety Key West proved the most prolific. In a further experiment in the

cultivation of yams those furnished stake supports far outyielded those not supplied with supports.

The chemical work on the effect of fertilizers on rice production has been concluded and the results are being prepared for publication. The outstanding facts brought out by this investigation were the reaction of the soil to fertilizers and plant growth, the effect of nitrogenous fertilizers on chlorosis and calcareous soils, and the influence of different fertilizers on the assimilation of nitrogen and iron by the rice plant. Some of the deductions from these experiments are believed to be far reaching and of importance to all rice growers.

The entomologist is continuing investigations on the possibility of the transmission of the mosaic disease of sugar cane by insects, and during the year he had under investigation in the insectary five or six species of insects that are frequently met with in cane fields. Studies are also in progress on the life history of the cattle tick in Porto Rico with a view to its eradication. As a result of a campaign begun by the station several years ago there are now 90 dipping vats in the island, and a sentiment for tick eradication is being rapidly developed. In connection with the investigation on the life history of the cattle tick a study is being made of ticks which infest other domestic animals. The mosquito survey of Mayaguez has been concluded and the results are given in a station publication. A system of mosquito control was suggested, and its application rests with the authorities.

The station has been quite active in the propagation and distribution of economic plants, commercial supplies of which are very limited. One of the striking results of this work is shown in the greatly increased planting of trees, not only on farms but also in municipalities, where the station is cooperating with the authorities in planting trees in streets and parks.

The San Juan office has kept in close touch with the citrus-fruit growers and is making studies on the cost of production, shipping losses, etc. A considerable amount of work has been done on the relation of temperature and humidity to the keeping quality of the fruit during storage and shipment. The activities along extension lines are largely directed from this office, and the issuing of Extension Notes, a mimeographed publication, is being continued. These notes are given wide distribution throughout the island and they are well received by the agricultural people.

The Porto Rico station is very much in need of a plant pathologist, the position having been vacant on account of a lack of funds since December, 1918. The citrus industry has developed until the exports in 1920 were valued at \$2,166,317, but there are a number of orchard diseases that need studying. Attention should also be given to decay during shipment, as much of the fruit arriving at New York must be sorted and repacked, at great loss to the growers.

GUAM STATION.

The work of the Guam station was somewhat curtailed during the year, due to a lack of funds to meet the increased cost of labor and materials. Considerable repair work was done and the station prop-

erty was protected from further damage by the elements. The investigations were continued along about the same lines as described in the previous report.

In animal husbandry the breeding, feeding, and care of the stock received attention and all the herds and flocks had satisfactory increases. The work in grading up the live stock was continued, so far as the resources of the station would admit, and this work is attracting much attention. In order to successfully continue the stock improvement additional purebred animals are needed but with the present income they can not be purchased. The transportation of stock to Guam offers many difficulties. The regular Army transports, plying between San Francisco and Guam, will not carry live stock and the only means by which they can be shipped is by Navy transports that are not properly equipped for the purpose. All the animal introductions made in 1920 continue in good condition except the purebred Berkshire swine. Two of the sows died during the year. Considerable attention has continued to be given to feeding native products to all kinds of stock. It was found that copra meal could be fed horses to the extent of 50 per cent of the concentrate ration and the animals keep in good condition. It also proved a satisfactory feed for cattle but it was necessary to mix it with other feeds to get the animals to eat it in sufficient quantity. When fed in combination with corn and rice bran, copra meal proved very satisfactory for dairy cows. When fed to swine in combination with damaged rice and cooked beans, satisfactory gains were made by young pigs, and on copra meal and fresh cassava older breeding stock kept in good condition. A common shrub in Guam is tangan-tangan (*Leucaena glauca*) upon which stock often browse. However, it is in bad repute, as it is commonly believed to cause the falling out of the hair. A feeding experiment was carried on to test this belief, green sprouts and twigs being fed to horses, cattle, goats, and swine. After a period of 12 days, during which no other green feed was given, the hair fell from the manes and tails of the horses, and after 3 months' feeding to swine, 3 of 10 became hairless. No injurious effect was noted with cattle and goats.

In the agronomy department continued attention is being given to forage crops investigations, since live-stock improvement is so closely associated with proper forage. A number of additional grasses were imported during the year and grown in comparison with Paspalum, Guinea, and Sudan grasses, all of which had been introduced some years before. Among the new introductions, *Pennisetum setosum*, Japanese cane, Guatemala, and Napier grasses gave satisfactory yields, and the green forage was greatly relished by stock. They all appear promising additions to the list of forage plants for Guam. In order to encourage the larger production and use of root crops the station conducted experiments with a number of different kinds, and the results will be available soon. In the progress of these experiments it was found that lowland taro, grown under conditions that kept the soil constantly moist, but not flooded, gave higher yields than when the plants were continually submerged to about one-fourth their height. Cooperative tests with rice were continued, and, although suffering much damage from rice bugs, a station selection gave larger yields than native rice. A variety

of upland rice introduced from Manila was grown on the station trial plats, and it matured early and produced at the rate of 625 pounds of clean, unhulled paddy, while some native rices grown near by did not produce any grain. Fertilizer experiments with rice showed that phosphorus in combination with ammonium sulphate gave the highest yields. Considerable attention is being given to leguminous crops for green manuring and as cover crops, and some of the more progressive farmers are beginning to recognize their importance in restoring the fertility of their soils. Among the best cover crops thus far tested are velvet beans, with Patani beans a close second. Cowpeas have proved successful under favorable conditions. During the past year a number of rice growers have planted their fields to sugar cane. Little is known as to the relative value of different varieties, and the station has begun a comparative test, which includes several varieties secured through the Bureau of Plant Industry of this department.

The horticultural work was restricted to keeping the station's plantings in as good a condition as possible with the limited amount of labor available, and to the growing of nursery stock for distribution. The requests for tropical fruit trees and vegetable seeds are becoming increasingly numerous. As there are no other available sources of supply, the station complies with the requests, so far as possible, but with the seeds sent out directions are given for saving seed, and it is gratifying to report that the people are adopting these suggestions to a very considerable extent. The plantings of vegetable crops in 1920 far exceeded those of any recent years.

The second year of agricultural-extension work in Guam was completed in March, 1921. The boys' and girls' clubs have proved extremely popular and the results obtained can not fail to have an important bearing on the future agriculture of the island. Clubs have been organized for the growing of corn, beans, root crops, and vegetables, and the raising of pigs and poultry. The total enrollment in all clubs at the end of the second year was 1,291, and 88.6 per cent of the membership completed the season's work and submitted written reports to the station. The value of the club products for the year was \$27,505, or an average of \$24 for each reporting member. The station is continuing to cooperate with the insular department of education in the operation of school gardens. Instruction is required in gardening at all rural schools and 11 gardens were maintained throughout the year, the station furnishing the outlines of instruction. The advantages accruing from the use of improved agricultural implements are constantly urged, and a considerable number of implements imported by the island government have been sold to farmers. In one district plows were used for the first time during the past year, and in another all land in crops was prepared with plows and the crops tilled with modern cultivators.

The work of the station for the ensuing year will be seriously handicapped through the departure of the agronomist and the extension agent. Both of these men were earnest and enthusiastic about their work, and they had developed their respective lines in a most satisfactory manner. Neither position has been filled on account of the reduced income of the station.

VIRGIN ISLANDS STATION.

A severe drought during 1920 and the first half of 1921 proved very trying to those engaged in agricultural pursuits in the Virgin Islands. The rainfall at the station from January 1, 1920, to December 31, 1920, was but 35.81 inches, very little of which fell during April, May, and June, when much of the crop planting is done. The rainfall from January 1 to June 30, 1921, was also very deficient and as a result much of the plat work of the station suffered severely. The work with sugar-cane seedlings was almost a total failure, and many of the new seedlings that were being grown in flats were lost. Some data were obtained on the field behavior of a few of the station's seedling varieties of cane, and the CS 12/4 is reported to have given increased yields over the common varieties grown on a number of plantations. Sufficient material of CS 12/4 was supplied the Mercedita plantation in Porto Rico to plant quite an area, and it gave a yield at the rate of $8\frac{1}{2}$ tons of 96° sugar per acre. While the season was too dry for cane in St. Croix it proved ideal for Sea-Island cotton, and a large crop would have been harvested had it not been for the presence of the pink bollworm in destructive numbers. The high prices obtained for their cotton in 1920 induced many planters to extend the areas devoted to this crop, but fields that gave promise of 1,500 pounds of seed cotton per acre actually yielded but 250 pounds. The presence of the pink bollworm in St. Croix was first reported early in 1921. Nothing is definitely known as to how it reached St. Croix, but the station is active in trying to secure the adoption of means for its control. The low prices and reduced yields have discouraged the cotton planters, and it is doubtful whether the industry will be restored soon to its former prosperity. The corn-breeding work, which was beginning to give promising results, was interrupted by the drought since planting in the early summer was prevented. As a result most of the seed that had been produced by crossing lost its viability. Some varieties of white corn introduced from Guam and Java gave satisfactory yields and proved excellent table corn if taken before the grain became hard.

During the past year the station gave considerable attention to the growing of vegetables. This is considered an important investigation, as the people of the Virgin Islands depend almost entirely on neighboring islands for their supplies of fresh fruits and vegetables. On account of the unfavorable weather, many failures were reported, but the general results indicate that in addition to the common tropical vegetables, such as sweet potatoes, yams, yautias, etc., tomatoes, sweet peppers, carrots, eggplant, kohl-rabi, and some varieties of string beans can be grown with the normal rainfall. Cucumbers, melons, squashes, beets, and some other crops were ruined by insect depredations, and these pests are being studied under local conditions to determine methods for their control. Considerable attention will continue to be given to vegetables, as the supplies are very inadequate, and they are considered essential to the diet of the people.

A beginning was made in the introduction and development of improved varieties of tropical fruits. A windbreak has been established and the rapid introduction of improved varieties of fruits is contemplated. Some avocados and seedling mango trees of the varie-

ties Amini and Cambodiana were received from the Porto Rico station, and they are making fair growth. A number of grapefruit and orange buds were inserted in lime trees on the station grounds, and they are doing well considering the unfavorable weather. Pineapples from Samoa have been set out, and papayas from a number of localities have been planted. There is a large demand for seed of the latter.

Considerable attention was given to forage and green-manure crops. The station has a 5-acre field of Napier, or elephant, grass that is well established, and cuttings of this valuable forage plant have been extensively distributed throughout the islands. One planter is said to have 10 acres now in this grass. Its value as a soil-ing crop during the recent prolonged drought has been demonstrated. Further tests have been made of velvet beans as a green-manure crop. A variety received from the Porto Rico station was planted in February and when cut in May yielded 12½ tons of vines per acre.

The entomologist has continued his survey of the insect fauna of the Virgin Islands. A scale insect, the ground pearl (*Margarodes formicarum*) was found abundant in sugar-cane stools. This is an addition to the extensive list published in the last report of the station. Especial attention was given to the insects found attacking truck crops, field crops, fruit trees, etc., with a view of determining methods for their control. A mosquito survey was made of St. Croix, and three species were found, only one of which, *Culex quinquefasciatus*, is important under present conditions.

During the year the station begun sending out Extension Notes in mimeographed form. Five of these were issued which popularly treated of various timely agricultural topics. The Virgin Islands are in need of extension work in agronomy and horticulture. The experiment station is located on the island of St. Croix, about 3 miles from Christiansted, and although but 40 or 50 miles from St. Thomas and St. John, its objects and work are wholly unknown to many of the people of the other islands. Extension and demonstration work should be taken up on St. Thomas and St. John, especially with fruits and vegetables. This would doubtless greatly stimulate their production and make available local supplies instead of the inadequate amounts now received from Porto Rico and Tortola. The people of St. Thomas especially need instruction in the elements of agriculture and gardening, as they so long depended on working about the harbor that they know little or nothing of modern methods of tilling the soil. Now, that there is so much less work connected with shipping, they should be trained to other pursuits, and agriculture appears at this time the most promising industry for them to take up.

OFFICE OF EXTENSION WORK IN THE SOUTH.

J. A. EVANS, *Chief.*

W. B. MERCIER, *Assistant Chief.*

The Office of Extension Work in the South has charge of the co-operative extension work of the Department of Agriculture in the 15 Southern States, viz., Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia. Its

functions, administrative organization, and relationships with subject-matter bureaus of the department and with the State extension services are the same as heretofore reported.

ADMINISTRATIVE FORCE.

The administrative force consists of a chief and an assistant chief, three field agents in the administration of the county agent and co-operative extension work in the States, four men and three women assistants in the administration of the home-demonstration work, and boys' and girls' club work; three executive assistants, and the necessary office and clerical force. The latter has been decreased during the year by about 20 persons, owing to changes and reorganization in the States Relations Service. There has also been a decrease of one in the administrative force of the home-demonstration work and girl's-club work since the last report. The office also maintains two Negro field agents, one with headquarters at Tuskegee Institute, Alabama, and the other with headquarters at Hampton Institute, Virginia; one with a territory of eight States and the other with a territory of seven. In the field, at the close of the year, the co-operative extension forces consisted of 15 directors, 16 State agents or assistant directors, 58 assistant State and district agents, 822 county agents, 39 assistant county agents, 154 Negro agents, 74 boys' club agents, 15 State home-demonstration agents, 73 assistant State home-demonstration agents, 483 county home-demonstration agents, and 84 Negro women agents: total 1,833. There were also six representatives of subject-matter bureaus of the department cooperating with the Office of Extension work in the South in taking technical information from the department to the States, and two field representatives cooperating with the Bureau of Entomology in the calcium-arsenate-poisoning campaign against the boll weevil.

FINANCES.

The total amount available for extension work in the 15 Southern States in 1920-21 was \$6,317,371. Of this amount the Federal Government contributed \$2,875,219.98, including \$494,800 from direct appropriations to the States Relations Service for farm-demonstration work, \$88,170 from appropriations to other bureaus of the Department of Agriculture, \$1,573,476 under the provisions of the Smith-Lever Act, and \$688,777 from funds appropriated to supplement the regular Smith-Lever funds. The States contributed \$2,112,253 to offset the latter two amounts. In addition, there were available from State and college funds, \$242,424; from county funds, \$1,050,621, and from other miscellaneous sources, \$66,850. These funds were used as follows: For administration, \$369,552; county-agent work, \$2,797,671; home-demonstration work, \$1,762,308; boys' agricultural club work, \$161,494; specialists, \$1,119,174; and publications, \$107.175.

COUNTY AGENTS.

In the development of county-agent work the administrative forces as well as the rank and file of the county agents realized the importance of returning to the fundamentals upon which the demon-

stration work was established, if rural conditions were to be improved and a well-balanced system of agriculture was to be brought about. The experience of carrying on work under the unsettled conditions of recent years, where the work covered a wide scope in a more or less indefinite way, has convinced most of them that the surest way to accomplish permanent results is to have a liberal number of concrete demonstrations with the standard crops well distributed over the entire territory. These demonstrations should be located with farmers who will cooperate and agree to keep records of results obtained. When a farmer follows the advice of the agent and produces a better crop at less cost, and consequently receives a greater net return for his labor, he has an object lesson more impressive than all the advice and propaganda that can be given by the best agricultural experts through meetings and speeches.

PLAN OF WORK.

Where the agricultural and home-demonstration agents have been recognized as the real leaders in their counties in all movements for the improvement of farm and home conditions by all forces attempting work with farmers, whether State or National, material progress has resulted. Such an understanding makes it possible for the supervising agents of the State colleges, the United States Department of Agriculture, and specialists and the leaders of any supporting farmers' organization to formulate a plan of work that is truly co-operative and adapted to the local conditions. Although the county agricultural agents are responsible for all work with men and boys' club work, and the home-demonstration agents for all women's work and girls' club work, it is gratifying to find a closer cooperation between them in carrying on activities in common. There is a growing feeling that the improved agricultural conditions for which the extension work was created can be brought about more quickly and effectively by team work than by each section of the organization operating on an independent basis.

All States in the South now require a definite written plan or outline of work for each county. This plan is usually formulated in a conference of representatives from county farmers' organizations with the county and district agents, both men and women, and the extension specialists interested in lines of work suitable to the county. After the plan has been carefully mapped out it is sent to the State office for suggestions and final approval. The plan provides for concrete demonstrations with the standard crops and live stock on the individual farms or by communities, special demonstrations along many lines, special campaigns for any important, new, and necessary lines of work, special, general, or field meetings, organization work, club rallies, or for any other authorized extension activity.

ORGANIZATIONS.

There are 5,882 community organizations in the Southern States which cooperate with the county agents in carrying out their county programs of work. These organizations in several States are now merged into farm bureaus with a paid membership. In other States organizations are still operated on a voluntary nonfee basis. In

either case the organization is active in assisting the agents in putting across their programs for the county development. Many of the leaders in the community and county organizations are valuable assistants to the agents.

One of the main purposes of the local organizations in the last few years has been to solve the difficult problem of marketing and distribution of farm products. Other lines, such as getting whole communities to grow one variety of crop or to use one breed of live stock have been promoted. This makes it possible to grade and standardize products for carload shipment.

After the sensational drop in the price of cotton in the fall of 1920 the extension forces in several cotton States, by the aid of the farmers' organizations and the business men in the cities and towns, put on a drive for reduction of the cotton acreage in 1921. This proved to be the most successful campaign of its kind ever launched. An average reduction of almost 30 per cent resulted. The same forces co-operated in calling meetings and suggesting to the farmers crops that could be substituted for cotton.

RESULTS.

About the time the extension organization in the South had made the necessary readjustments following the war period, the price of all farm products, especially of cotton, greatly declined. This naturally caused great demoralization in business and left the farmer unsettled and disturbed. Conditions were so bad that the farmers could not sell their products or secure further financial assistance to make preparation for another crop.

The 1920 crop was made at abnormal expense, so when the market suddenly dropped to a point below cost of production the agricultural interests of the South generally were depressed. Realizing the situation the extension organizations in the different States and the business men and other forces interested in agriculture cooperated in mapping out a plan of procedure for crop production in 1921. The leaders knew that if the cotton acreage was reduced suggestions and advice must be given as to how to utilize the surplus acreage thus released. Every member of the force did what was possible along this line. The problem of financing another crop was a serious one. Banks, merchants, and farmers were all heavily involved and had no market for their products. But the business men and farmers got together and agreed to do their best to produce the 1921 crop at the least possible expense. Full benefits from the safe farming campaigns of previous years were realized by many farmers in this emergency. Financial aid from the bankers and merchants being cut off, farmers were forced to depend upon the products of their dairy, live stock, poultry, and home garden for the family living, and in a large measure for extra funds with which to hire the necessary labor.

The live-stock industry which had made wonderful progress in recent years in the cotton territory was also dealt a hard blow by the falling off in prices of all kinds of animals. Many farmers who had bought good breeding stock became discouraged and sold them off at meat prices, but fortunately the county agents were able to prevent many valuable animals from being sold to butchers.

In spite of this condition there is yet a great interest in purebred live stock. A better-sire campaign was and is still being pushed. The dairying industry has made progress, also the poultry business. The boys' live stock club work and the girls' poultry club work have continued to grow in popularity and are probably the greatest factors in the promotion of the better live-stock industry in the cotton territory. The promotion of cooperative marketing of live stock was continued by the county agents during 1920-21, though not with the uniformly good results of previous years. The total number of hogs in the Southern States was 21,781,000. It was an increase of 18 per cent over the number in 1910. Twelve of the twenty-four States having the greatest number of hogs are in the southern territory.

The extension forces in all the cotton States have taken advantage of the present opportunity to promote in every way possible the campaign for a balanced farming system. The services of county agricultural agents have been in great demand for giving information on soil improvement, seed selection, food and feed crops, dairying, trucking, orchards, and other lines that will tend to prevent the recurrence of the present situation.

DEMONSTRATIONS.

Specific demonstrations conducted by the farmer on his own land under the guidance of agents and specialists are still regarded as a fundamental part of the county agent's work. The community demonstration serves its purpose as an object lesson for the community in which cooperative organizations are functioning, but it can not take the place of individual demonstrations from which concrete results can be secured. The community demonstration may be used for examples in soil improvement, orchards, cooperative marketing, and other things of general interest.

The total number of acres in crop demonstrations in 1920 was 2,274,554; the total number of farmers demonstrating was 230,819. These demonstrations have dealt with all the more important phases of crop and live-stock production in the South, as well as with cooperative marketing and purchasing. The largest acreage in demonstrations with one crop was that of corn. More than 57,199 demonstrators cultivated a total of 539,794 acres under special instruction, with an average yield of 41.6 bushels, or more than double the average yield of the whole territory. Like results were obtained from demonstrations with the staple crops, such as cotton, oats, wheat, legumes, potatoes, etc.

The county agents were specially active during the year in urging the terracing and drainage of lands, in promoting the use of better seed for all farm crops, in placing flocks of good poultry with special attention to culling, in extending the practice of liming soils, and in securing the protection of crops and live stock against the ravages of diseases and pests. They have also done what they could to promote tick eradication and the prevention of hog cholera, blackleg, and anthrax.

Work relating to cooperative marketing and purchasing was one of the outstanding projects carried on by the extension agents during the year. The county agents, assisted by marketing specialists, through marketing demonstrations and by instruction and advice,

have aided local and county associations of farmers in the cooperative selling of all kinds of farm produce and live stock and in the cooperative purchasing of many farm necessities.

In many of the States the Bureau of Markets of the United States Department of Agriculture has specialists in marketing working in cooperation with the extension divisions of the colleges. In a number of the States State departments of agriculture and the extension divisions of the agricultural colleges cooperate closely in this activity. The total value of all products cooperatively marketed and purchased through the assistance and advice of the county agents during the year was \$59,676,488, representing a saving of \$6,544,021, or about 11 per cent of the total volume of business.

As the result of the knowledge gained from experience in cooperative marketing, the farmers have organized in many places county-wide or even State-wide commodity-marketing organizations. The growers of the main cash crops—cotton, tobacco, peanuts, sweet potatoes, hay, fruits, and some truck crops—have either organized or are in process of organizing.

The cooperative work in cotton grading and stapling, and the information given as to the marketing value of the various grades and staples by the extension divisions in cooperation with the Bureau of Markets, saved the cotton farmers millions of dollars in the marketing of their cotton crop alone.

The important feature brought out by the experience in the cooperative marketing work is that in order to get good prices for their products, the farmers must be shown the necessity for growing the products that the people want, and after these have been grown, to see that they are properly graded and packed before shipment. The extension divisions, especially the marketing section, have devoted much time to teaching the people these important points in marketing.

HOME-DEMONSTRATION WORK.

In the adjustment of home-demonstration work to the after-war conditions the outstanding feature of last year's work in the Southern States has been the general effort to increase the home production and preparation of food material and other things needed in the farm home. Greatly increased interest has been shown in meat curing and canning, in butter making, and in home gardening and fruit growing. In 1920 the members of the home-demonstration clubs cured, according to standard methods, 9,477,988 pounds of meat and 2,173,626 pounds of sausage against 6,643,555 and 1,661,857 pounds, respectively, in 1919. A total of 2,648,686 pounds of lard was rendered for home use in 1920 as against 2,559,993 pounds the previous year. Canning of meats and fish under steam pressure has proved the best way for farmers to keep meat in other than cured form. This is shown by the fact that 228,503 containers were canned against only 217,784 in 1919 and 126,665 containers in 1918. These containers were pint and quart glass jars and tin cans of corresponding sizes. Combination packs of meat and vegetables or fish and vegetables, whereby a practically balanced meal is prepared and canned, are rapidly gaining favor. It is of great interest to notice that for these products old southern recipes that have descended from the early set-

tlers have been revived and standardized. Among these dishes are Dixie burgoo, pine bark fish stew, and creole jambalaya.

This increased food production and the combination packs of meats and vegetables are direct results of the efforts of home-demonstration agents to get the women to demonstrate and use in their homes balanced meals and dietaries for greater efficiency, and for the prevention of diseases like pellagra, scurvy, and, to some extent, tuberculosis. Nutrition demonstrations have been given and the effect of butter and milk in the daily diet has been stressed with the result that a greater interest has been taken in home dairy work. A membership of 10,435 were enrolled in butter work, and 686,471 pounds were reported made under demonstration methods against 488,074 pounds in 1919. Part of this butter has been sold, and brought an average of 13 cents above ordinary market price for farm butter. Still the home consumption of this demonstration butter was 137,598 pounds more than in 1919. The proper place of milk in the diet of children has been demonstrated, and the consumption of milk by them has increased. As a result of the home-demonstration agents' activity for bettering the children's diet, 724 additional schools have been induced to secure milk for the children's lunch against 469 schools the previous year, and 3,023 family cows were placed on farms not having cows previously. A similar result in home consumption of poultry-club products is also noticeable. The use of eggs in the diet has increased considerably, 1,466,419 dozen eggs having been used in homes in comparison with only 807,808 dozen in 1919.

Supplementing the effort to secure increased production of food for home consumption there has been an effort to sell to better advantage the unused surplus. This has led to more careful selection, better standardization, and to the increased manufacturing of the raw products for market, whereby not only the growers' but the manufacturers' profit can be secured. As a result of this effort curb markets and local exchanges have been established in a number of towns to provide a better market. More than 100 of these little markets are now doing \$1,000,000 worth of business annually. Many cases have been reported where the mothers and daughters have made more profit on the home enterprises than the fathers and sons did on the farms. The products sold by the girls and women include fresh and canned vegetables and fruits, poultry products (eggs and live and dressed poultry), and dairy products, such as cream, butter, and cottage cheese. Surplus hogs fattened for market have not been sold on foot, but have been butchered and manufactured into pork sausage, lard, and scrapple, and then sold. Thereby a greater profit has been secured than if the hogs had been sold alive, and home thrift and industry have been strengthened.

Over 238,000 women and girls were enrolled in 1920 as demonstrators in home-demonstration and girls' clubs. The usual activities of the clubs have been continued. It is, however, interesting to notice the large increase in home gardens and permanent gardens, orchards, and vineyards.

In the girls' work alone there were 179,972 summer, winter, and perennial gardens. The total value of the products produced by the girls in these gardens amounted to over \$1,500,000. Over 5,000,000

quarts of fruits and vegetables were canned by them and large amounts of vegetables and fruits were dried or brined, besides what was sold fresh. The girls do not, however, confine their work to gardening, but are also active in dairy work, poultry work, and in the beautification of the farmstead. In the poultry clubs 36,766 girls were enrolled, and with the 27,300 women members they produced poultry club products to a value of over \$2,500,000. The success of the girls' work with standard-bred chickens is mainly responsible for the increased interest taken by the women and is resulting in the elimination of the scrub hen and the poor layer. Over 1,600,000 pure-bred chickens were raised, 183 egg circles were established, and 184 poultry breeding associations organized.

The girls are also making much progress in the baking of good bread, the preparation of balanced meals, and the making of uniforms, caps, and aprons. The principles of home arrangement and beautification are demonstrated by the girls in furnishing and decorating their own rooms and in helping with the general improvement of the farmstead.

From the girls' demonstrations in standardizing and marketing of club products they are learning thrift and business methods. It is interesting to see how they spend their increased earnings. Three hundred and sixty girls were attending normal schools, agricultural schools, or colleges on scholarships awarded for excellency in achievements, and 1,880 girls were paying all or part of their school and college expenses out of money earned from the sale of club products.

The membership of women in the home-demonstration clubs is rapidly increasing. Large numbers of women who are not club members are influenced through the demonstrations carried on by the members for the benefit of themselves and their neighbors to adapt more or less of the club work to their daily home life. In fact, it is estimated that every good demonstration influences from 5 to 10 people to follow the example in whole or in part.

The first step in the women's work as in the girls' work is to increase the earning capacity of the home. This is done partly by producing food material that was not produced before, partly by standardizing for marketing purposes the surplus produced on the farm, thereby securing better prices, and partly by introducing labor-saving devices to eliminate much of the drudgery and thus conduce to better system and greater thrift in the daily home life.

The women grew 195,343 gardens and established 16,525 home orchards and vineyards in 1920. They canned over 11,000,000 quarts of fruits and vegetables and over 2,000,000 pints of jellies and marmalades. They made 153,101 gallons of vinegar and 106,512 gallons of fruit juice. They stored over 1,000,000 pounds of dried fruits and vegetables and preserved in brine more than 3,500,000 pounds. Besides the butter made, they sold over 2,000,000 pounds of cream and have, together with the girls, produced poultry products worth \$2,534,171.88. They have learned to serve balanced meals from the products raised on the farm, and demonstrated thirft in remodeling and dyeing of clothing. There are 322 club members demonstrating with Belgian hares and 1,206 are demonstrating with bees. They

established and stocked 150 fish ponds. Household budgets are made by 4,062 women and 8,689 are keeping accounts.

Home improvement and beautification are important parts of the women's work. During the year, 1,989 new homes were built according to home-demonstration plans, and 4,549 homes were remodeled. In 1919 the respective figures were 1,045 and 3,078. There were installed 2,354 lighting systems, 839 heating systems, 1,371 water systems, and 995 sleeping porches were built; 11,475 kitchens were improved; 29,303 labor-saving devices were made or purchased; 2,334 steam-pressure canners were bought, and 1,746 washing machines are reducing the hand labor in laundry work. In home beautification, 6,007 fences were straightened and repaired, 2,758 unsightly buildings removed or repaired, 2,110 lawns were established, 17,847 trees, 11,514 shrubs, and 21,213 vines and other plants were grown to beautify the home and improve its setting in the landscape. This shows that we are approaching the realization of the vision of the founder of home-demonstration work, who said:

The farm must be made a place of beauty, so attractive that every passing stranger inquires, "Who lives in that lovely home?" The house is of minor consideration; the gorgeous setting of trees and shrubbery holds the eye.

Home-demonstration work in the South is conducted through the activity of 474 county home-demonstration agents, assisted and directly supervised by 53 district home-demonstration agents, who again are under the guidance of a State home-demonstration agent. The State home-demonstration agent is directly responsible to the director of extension. There are 18 assistant State demonstration agents and 36 specialists in the different subjects to give technical assistance and help wherever needed.

On account of the difficult financial conditions in many of the southern counties the number of agents was reduced to some extent during the last year. This reduction was, however, shown in the first place in the number of assistant county home-demonstration agents. There were 474 counties in July, 1921, having a home-demonstration agent against 565 counties in July, 1920. One State kept its number of counties unchanged; in five States the number of counties with home-demonstration agents was increased by 15. In 42 counties in 9 States the work was given up. This was not because of dissatisfaction with the results, but only because of the scarcity of available local funds. It shows the local people's appreciation of the home-demonstration work that it has been so well supported under the present economic conditions. With such local support and with an increase in the proportion of Federal and State funds as the extension act comes to maturity there is all reason to expect greater development in this line in the near future.

BOYS' CLUB WORK.

Boys' club work in the Southern States has taken on a permanent aspect which is gratifying. Work with individuals is being superseded by work based on organized boyhood that does not need rejuvenating at the beginning of each year. The county agent has in many instances multiplied his efforts by securing the aid of public-spirited citizens, who take an active part in serving as his local leaders and in keeping something for the boys to do during the entire year. The

boy is given an opportunity to satisfy his intense longing to do worthwhile things, and is made to realize that he is of some importance in the life of the community. Advantage is taken of the "gang" spirit common to all boys by arousing interest in cooperative work and play. By proper direction this spirit is caused to function in forming a boys' club. This group is usually enlarged into a boys' and girls' agricultural club, and finally into a community club. The community score card is adopted, which stimulates local pride and friendly rivalry between communities. This score card is partly based on the combined records of the demonstrators, therefore the club as a whole is interested in the success of each individual demonstration. Community prizes are offered in the county in the form of moving-picture machines, graphophones, libraries, etc.

CAMP TRAINING.

In addition to instruction given by the county agent at group meetings held at the home of some member, one or more 4-H camps are held. The instruction received at the 4-H camp has an appeal to the boy that is far reaching and permanent. An Alabama boy attending a camp said: "I got out on the public road and began to dig stumps to make money for this trip." The camp is usually conducted from 2 to 10 days, instruction in club activities being given. Supplementary work is also given which appeals to the human side of life by physical training and wholesome entertainment in the form of games, songs, and other recreation.

Properly directed play develops leadership and training most necessary in everyday life. The boy learns to subordinate his wishes to the good of the group. Through the cooperation of bankers and business men instruction is given in business transactions, while first-aid demonstrations and physical examinations, showing diseases and malnutrition, are conducted by Red Cross representatives and physicians. Many boys leave the camp with a new hope in their hearts. They gain a new vision of life and feel confidence in their ability to help raise rural standards. In some instances the county camp functions as a clearing house for the live-stock judging teams. The team selected is composed of boys who have done satisfactory demonstration work in crops or animals, and may represent one community or different parts of the county. Friendly community rivalry and pride cause interest in this contest to run high. The love for contest and achievement impels thousands of boys to really know a good animal when they see it. Those fortunate enough to make the county team are sent to the State 4-H camp, where the selection of the State team is made. Perhaps no other phase of club work has such great value in holding the older boys in club work. The State 4-H camp is conducted in much the same manner as the county camp, but along more advanced lines. The boys build hog houses and self-feeders, run tractors and other improved machinery, and study gas engines and pipe fittings.

ECONOMIC VALUE.

Boys' club work has become recognized as of such value that the business men and bankers of the Southern States loaned or donated to it more than \$659,000 in 1920. Club members have introduced pure-

bred live stock and seed into sections where they were practically unknown. By following improved methods boys were enabled to produce 57 bushels of corn per acre, as compared with 41.6 bushels produced by adult demonstrators and the average yield of the Southern States of 22.6 bushels. The 113,861 boys enrolled produced agricultural products with the total value of \$4,263,554.90. This remarkable record does credit to the club boys, but of infinitely greater value is the directing of boyhood dreams into worthy deeds of manhood. Through profit-bearing achievement confidence is inspired and ambition aroused to attack and solve the problems of life. Such methods are going a long way toward holding the best brain and brawn of the country on the farm.

NEGRO AGENTS.

A considerable proportion of the results reported under the head of the county-agent work each year is from the work with Negro farmers. However, in most of the Southern States there is maintained also a force of Negro men and women agents to work in the counties thickly populated with members of their race. This force at the close of the year consisted of 2 field agents, 154 Negro men agents, including State and district supervisors, and 84 women Negro home demonstration agents. The work is financed on the same basis as the white work and is under the general supervision of the white administrative forces in the States. It is carried on as far as possible in cooperation with the Negro agricultural colleges. Naturally the work makes greater progress in communities and States which come under the influence of Negro schools which have the agricultural viewpoint. One of the results of cooperating with these institutions is gradually to bring about within the institution a better appreciation of the need of agricultural education for the Negro.

The two field agents in Negro work, cooperating with the State directors and other white supervising agents, assist in the organization of the Negro work in the States, help to develop plans of work, prepare reports, and assist in every way possible in maintaining the proper spirit and harmonious relations between the races in their respective territories.

The general outline of the work carried on during the past year is very similar to that in previous years. The Negro work deals with fundamental things looking to the adoption of a self-supporting farming program on every farm. The kind of extension work carried on by these Negro agents is identical with that of the white agents as far as conditions will justify and the ability of the worker and the people served make them capable of receiving the work. The Negro agents have more intimate contact with the people in their territories than do the white agents. In speaking of this, one of the Negro field agents has said:

The demonstration agent becomes not only a medium of agricultural instruction, but a social stimulant in the backward communities. They get into the life of the farmers, the boys, the girls, and the parents. First, by gaining their confidence. They talk with them in their own common language about their many problems, real and imaginary; they spend the nights with them around

their firesides and listen to interesting stories containing local history of the surrounding community; they break down superstition; they help make the sympathy of the two races nearer one, and they do untold good toward gaining for the South more intelligent, peaceful, and contented citizens.

The reports from the workers indicate that on a whole the results of last year's activities in Negro work are decidedly encouraging in all lines. A general improvement in the farms owned and operated by Negroes is noted. They are building better homes, acquiring better live stock, starting orchards, pastures, and gardens, and there is being aroused a very decided sentiment for better schools, churches, and roads.

The men agents during 1920 listed 500 demonstrators and 39,784 cooperators in corn. The demonstration yields were nearly twice the yields of corn grown on adjoining farms and worked under ordinary methods. They reported 6,778 of their demonstrators and cooperators who field selected their seed corn for the following year's planting. In cotton they listed 1,917 demonstrators and 15,444 cooperators, with 3,378 of these cotton farmers selecting seed for the following year. They reported 27,838 demonstrators and cooperators in small grains, and more than 50 per cent of the Negro farmers listed were reported as having enough grain and forage to run their farms; a remarkable showing compared with the situation a few years back. The introduction of forage and hay crops among Negro farmers is a new departure with many of them. The pure-bred live stock reported purchased by Negro demonstrators consisted of 377 horses, 1,688 dairy cattle, 149 beef cattle, 2,848 hogs, and 700 sheep; 3,500 head of grade cattle were also reported purchased. One thousand three hundred and eighty-five demonstrations with poultry were carried on.

Home improvements listed were as follows: New houses built, 4,488; houses improved, 11,358; and the improvement in some way of sanitary conditions in many thousands of homes.

In the work of the Negro women home demonstration agents perhaps more has been accomplished in improving living conditions, considering the limited number of women reached by them, than in any other branch of the service. Not only were living conditions in the home improved, but valuable instructions and demonstrations were given in sanitation, improving the home surroundings, in equipping the home, in the preparation of food, and the selection and making of clothing. One notable feature is the assistance and advice which has been given in the care of children and in sickness of all kinds. In one State a rural health nurse has been working in cooperation with the movable school employees in Negro work and has been able to arouse greater interest in better health, improved sanitation, and improved living conditions.

Club work is also carried on by Negro agents, farm makers' clubs for boys and garden and canning clubs for the girls being organized in all of the States. Some notable results have been achieved by the boys and girls in these clubs. Total enrollment in the cotton clubs for 1920 was 50,104, animal clubs, 18,366. The products of the club members reporting, at the market price, are valued at approximately \$450,000.

The work with Negroes by the Negro agents has given such substantial outstanding results that it is felt the number of agents, particularly the home-demonstration agents, should be increased in a number of the States.

A moving-picture film showing the activities of the Negro agents, prepared by the department, has been widely shown throughout the country and has materially aided in helping to spread general understanding of the nature, purposes, and results of this phase of extension work.

Successful Negro short courses have been held at a number of the Negro agricultural schools, with attendance ranging from 300 to 600 of the leading farmers of the race.

EXTENSION SPECIALISTS.

Much progress has been made in systematizing the work of the extension specialists connected with the agricultural colleges and in correlating their work with that of the county agents. The number of subject-matter specialists employed has been reduced in some of the States. Excellent service has been rendered by many of these specialists. The necessity for a reasonable staff of well-trained specialists to assist the county agents in handling unusual problems, particularly in the control of diseases of plants and animals, in special lines of horticultural work, etc., is recognized. There is, however, need of further consideration regarding the character and extent of service which can be profitably performed by extension specialists and what constitutes true economy in the expenditure of funds for their support.

OUTLOOK.

The outlook for extension work in the South was never better. It is believed that we have almost passed through the period of readjustment due to depressed economic and postwar conditions. In most of the States, in spite of the extreme depressed economic conditions of the past year, full appropriations have been made for offsetting Smith-Lever funds, and comparatively few counties have failed to make their appropriations for county-agent work, and in all of these cases it is felt that ground will be regained as soon as economic conditions become partly normal.

The farmers of the South are better organized than ever before and the farmers' organizations of every kind are heartily supporting and cooperating with the extension work. This will make it possible to do even more effective work in the future.

OFFICE OF EXTENSION WORK IN THE NORTH AND WEST.

C. B. SMITH, *Chief.*

Extension work in the Northern and Western States developed normally throughout the year, the effort of extension forces being centered not so much on expansion as on efficiency. A phase of this work has been the setting of definite goals to be reached in each community by each of the leaders of the several lines of farm and home-improvement work undertaken. Thus, instead of a general

plan for live stock, crop, home, and community improvement there has been an effort to set specific goals of accomplishment in each of these lines, such as the building of 5 silos in the community; the establishment of 10 fields of alfalfa on as many farms; the putting in of a system of running water in 3 farm homes; the bringing into the community of 3 purebred bulls and the organization of 1 live stock-shipping association. To definiteness of this kind has been added increased responsibility of the local leadership in carrying out programs thus agreed upon. The art of developing an agricultural and home program of work through the agency of the people themselves in conference with the agents of Government has been greatly advanced, so that probably half of the extension work now being done is on this basis, and the principle has been accepted practically everywhere as wholly sound.

The county-agent work shows a growth of 68 additional counties employing full-time agents during the year, making a total of 1,213 counties with agents on June 30, 1921, the highest number since the work began in 1911. Certain confusion as to the character of these agents, arising from the insistence of farmers and their organizations in some regions that the county agents should engage in activities outside of extension work during the past two years, has been cleared up by the general recognition that if any public money is involved in their support they should be regarded as public agents and keep within the limitations appropriate to such agents.

Home-demonstration work made a modest growth during the year, there being a total of 239 counties and 13 cities organized with agents at the end of the year. Women are being increasingly recognized in extension work. In many States they have voting power equal with men in the county farm bureaus supporting extension work and take their place with the men in developing local programs of work.

The boys' and girls' club work has maintained its popularity and is being increasingly recognized as a most efficient agency in securing the adoption of better agricultural and home practices. The work is more and more becoming a part of the agricultural program developed in each community. Fathers and mothers take satisfaction in a plan which enables their sons and daughters to work with them in improving agricultural practices for the home and community.

Farm-management demonstration work is being so modified as to reach larger numbers of people by the group method of opening and closing accounts and the working out of simple efficiency factors based on the year's business. Greater consideration has also been given to problems of tenancy and the relation of production to cost and price. This work is getting an increasingly stronger hold on both county agents and farmers as the work continues from year to year.

Finances.—The total funds available for extension work in 1920-1921 in the Northern and Western States was \$10,519,371. Of this amount the Federal Government contributed \$3,436,126, including \$532,050 appropriated directly to the States Relations Service for farm-demonstration work, \$86,325 from appropriations to other bureaus of the Department of Agriculture, \$2,006,528 under the provisions of the Smith-Lever Act, and \$811,223 from funds appro-

priated to supplement the regular Smith-Lever funds. As an offset to the latter two amounts, the States contributed \$2,487,751. In addition, there was available from the States and colleges \$1,375,522; from county funds, \$2,437,606; and from other miscellaneous sources, \$782,366. These funds were used as follows: For administration, \$581,633; printing and distribution of publications, \$138,627; county-agent work, \$5,668,548; extension work with women, \$1,383,447; boys' and girls' club work, \$947,618; and extension specialists, \$1,799,498.

Publications.—During the year the following circulars were prepared for distribution: The Farm Woman's Problems; Status and Results of County-Agent Work, Northern and Western States, 1920; Status and Results of Home-Demonstration Work, Northern and Western States, 1920; Status and Results of Boys' and Girls' Club Work, Northern and Western States, 1920; Boys' and Girls' Clubs Enrich Country Life (Yearbook 1920).

COUNTY-AGENT WORK.

The number of county agents has increased to the point where at the close of the year more counties were cooperating in the employment of county agricultural agents than during the war. In other words, sufficient gain has been made to more than offset the loss in counties resulting from the withdrawal of emergency appropriations by Congress following the war. On June 30, 1921, 1,213 counties were cooperating in the employment of county agricultural agents. This is a gain of 68 counties since June 30, 1920. The number of district agents remained about the same—12 in 1921, as compared with 10 the year before. In addition there were 124 assistant county agents, 33 county-agent leaders, and 63 assistant leaders, making a total of 1,445 field workers.

The work has now passed through the "readjustment" period and may be expected to continue to make steady gains until the remaining agricultural counties of these States are supplied by county agents.

TENTH ANNIVERSARY OF THE WORK.

This year witnessed the tenth anniversary of the starting of county-agent work in the Northern and Western States. On March 21, 1911, John Barron began work in Broome County, N. Y., as an agent of the Federal Department of Agriculture, cooperating with the Binghamton Chamber of Commerce and the Delaware, Lackawanna & Western Railroad. While there was no official cooperation with the New York State College of Agriculture at the outset, the college recommended the appointee for the place, and in carrying on the work its advice was freely asked and freely given. The work was indirectly a result of the interest aroused by "The Country Life Commission," appointed by President Roosevelt and headed by L. H. Bailey. The work of this commission attracted nation-wide attention and aroused public interest in the problems of rural life. When the Broome County, N. Y., people sought the advice of W. J. Spillman, then Chief of the Office of Farm Management, as to how they could best assist agricultural development in that

county, he advised the employment of a man to devote full time to working with farmers in the Binghamton quadrangle. This area was later restricted to the county boundaries. The Chamber of Commerce at Binghamton had been chiefly responsible in awakening local interest in the movement and this at first was confined almost entirely to the city. The Delaware, Lackawanna & Western Railroad, which had a demonstration-farm project in mind, gave this up and joined with the Chamber of Commerce and the United States Department of Agriculture in financing the work, share and share alike. The agent was given an office in the Chamber of Commerce and made manager of a new department of this organization which was called a farm bureau. The farmers were not wholly content with this organization, and before long took over the farm bureau and made it a separate organization under their own control. Three additional county agents were appointed in New York during 1911 in Jefferson, Delaware, and Chemung Counties, and one in Sussex County, N. J. The fiscal year closing June 30, 1913, really marks the beginning of the work in an organized way, for about 100 county agents were appointed in 19 of the 33 Northern and Western States that year, as a result of a Federal appropriation for this type of work.

PROGRAM OF DEVELOPMENT.

While the county continues to be the unit for administrative purposes, the community seems to be a better unit of operation than the county, so far as program development and execution are concerned. Increased emphasis has been placed on "sources of income" as a basis for determining what should be undertaken in the way of an agricultural program. In the working out of a community program the community committees decide:

1. What are the chief sources of income in crop and live-stock production.
2. What are the limiting factors.
3. What can be done.

Having determined what to do, a community project or plan of operation is developed, which determines the which, when, where, who, and how much of the undertaking:

- (1) Which of the limiting factors will be attacked this year.
- (2) When in the year will the work be done.
- (3) Where in the community will the demonstrations be located.
- (4) Who will be appointed community leader responsible for attending to local details.
- (5) How much will be undertaken; the goal of achievement.

The above matters are considered at meetings of a few interested people, usually at the home of a member of the community. Later they are publicly discussed at a meeting to which the whole community is invited. The value lies not only in "program development," but principally in helping the community in self-analysis, which is the sound basis of all progress. The establishment of definite "community goals" in connection with extension work was first introduced in community program building in a few counties in Washington State two years ago. It has been adopted in more than half of the States, and is becoming an accepted principle of program development.

There were in 1920 11,561 of these community committees which held a total of 9,086 meetings, or an average of about 14 per county reporting. There were in addition 31,914 community-wide meetings held in connection with the forwarding of programs of work, or an average of about 35 per county per year. The total attendance at these meetings was 1,214,551, or about 40 persons per meeting.

SUPERVISION.

There was a marked tendency on the part of all county-agent leaders during the year to better supervise the work in the counties. Methods of analyzing the status of the work on a county wide or on a State-wide basis have been devised by this office and adapted to the use of the various States. The practice of studying the present conduct of the work is resulting in the discarding of false ideals and the placing of greater emphasis upon those features of the organization of the work productive of optimum results. The supervisory plans of county-agent leaders are being largely based upon the needs of the work throughout the State and in the various counties as brought out by careful analyses. More attention is being given to following up the programs of work outlined in the counties at the beginning of the year to see that they are being carried to satisfactory completion. County agents are particularly desirous of this kind of assistance from supervisory officers.

DEMONSTRATIONS.

The number of field demonstrations conducted by agents decreased somewhat over previous years. This doubtless was largely due to the unsettled economic conditions affecting agriculture and the increased attention given by agents to problems of marketing and cooperative organization. These demonstrations covered almost every phase of crop and live-stock production including work with cereals, legumes, potatoes, orchards, dairying, beef cattle, swine, sheep, poultry, drainage, irrigation, fertilizers, insects, plant diseases, animal pests, silo construction, and weed eradication. The following table contains a summary of demonstrations per agent reporting 1916-1920:

Summary of demonstrations, 1916-1920.

Item.	1916	1917	1918	1919	1920	Average for 5 years.
Number of demonstrations per agent.....	80	64	69	82	47	68
Number of demonstration meetings per agent.....	25	24	29	50	31	32
Attendance at demonstration meetings per agent.....	642	741	598	753	586	667
Profits from demonstrations per agent.....		\$8,817	\$19,600	\$20,267	\$10,393	\$14,891

In connection with the work with soils it is interesting to note that the new area brought into profitable production through drainage or irrigation equals the area of six average Ohio counties. In connection with crop production 52,556 farmers were assisted in securing

1,345,562 bushels of improved seed, and 19,694 farmers were helped to grow 2,925,855 bushels of improved seed for sale.

In rodent-control work 15,942,460 acres of farm and range land were involved and 2,029,242 pounds of poisoned bait distributed. In insect-control work 3,394,368 acres were involved in connection with which 8,873,599 pounds of poisoned bait were used.

In connection with work with live stock 183,269 cows were under test for production in 555 cow-test associations. Farmers were assisted in purchasing 35,863 purebred sires and females, 232,700 animals were tested for tuberculosis, 287,694 animals treated for blackleg, and 412,811 hogs vaccinated for cholera. Under farm management 71,642 farm-account books were distributed in 848 counties. The agents assisted in organizing 5,720 boys and girls' clubs with a total enrollment of 72,847.

MARKETING.

Sixty-one per cent of the agents employed in 1920 report assistance given in connection with the organization of cooperative enterprises. The amount of business transacted and the savings effected have been difficult for agents to ascertain owing to the frequent change of agents in the counties and their inability to secure statements from associations in the county whose organization had been effected by the agent or his predecessor. Because of incomplete data the statements made in the following table are a very conservative exhibit of the work of the county agents along this line. This conservatism is indicated by the fact that while 798 agents in 1920 reported assistance in cooperative marketing work, but 586 gave the amount of business done by the associations and but 503 reported savings effected.

Cooperative business associations organized on the advice of county agents and amount of business done.

Item.	1915	1916	1917	1918	1919	1920
Number of agents assisting in organizing cooperative enterprises.....	61	98	150	322	429	798
Percent of total agents at work involved.....	17	22	24	30	37	61
Amount of business done through organization which was effected through influence of agent or predecessor.....	\$3,764,783	\$6,357,562	\$19,338,783	\$41,875,783	\$60,762,177	\$375,714,660
Savings by cooperative organization which were effected by company agent or predecessor.....	\$275,375	\$741,600	\$1,419,937	\$3,307,783	\$5,434,593	\$21,152,773
Amounts of business per agent involved in assisting in organization of cooperative enterprises.....	\$42,798	\$66,913	\$129,225	\$140,995	\$141,636	\$626,191
Amount of saving per agent involved in assisting in organizing cooperative enterprises.....	\$2,972	\$5,800	\$9,725	\$9,780	\$12,668	\$43,304

The increased interest in cooperative business enterprises, as indicated both by the number of agents reporting work of this character and the total volume of business done by such cooperative organiza-

tions, is indicative of the greatly increased interest on the part of farmers in marketing activities and no doubt accounts in a large measure for the decrease in the number of field demonstrations conducted during the year.

OUTLOOK.

The problem of personnel is not nearly so acute as it was a year ago. Increased salaries and lessened competition for men in the commercial field have caused new agents to stay in the work and old agents to return to the work. During the 10 years the work has been under way it has proven its worth. It has been accepted by American farmers and is no longer a trial or experiment. It has brought the agricultural college, the United States Department of Agriculture, and the farmer into a working relation. It has awakened the farmers' economic interest and has laid the basis for the rebuilding of social life in the county. The problems of the immediate future are increased efficiency and the gradual expansion of the system to include the remaining agricultural counties.

EXTENSION WORK WITH WOMEN.

This section of the work had a force of 30 State leaders, 19 assistant State leaders, home-demonstration agents in 239 counties and 13 cities, and 10 district home-demonstration agents on June 30, 1921. Aiding this home-demonstration force were 78 specialists employed as follows: Twenty-five in clothing, 21 in foods and nutrition, 9 in household management, 5 in home health, 12 in general home economics, 2 in poultry, and 7 miscellaneous. An outstanding development of the past year was the increased number of rural women who have acted as local leaders. Seventeen thousand three hundred and seventy-nine local leaders were secured through the 3,015 training groups held for local leaders by home-demonstration agents, which had a total attendance of 34,491. Seventeen thousand three hundred and ninety-nine local groups carried out work in extension projects, reporting 71,071 home and community demonstrations established from which 108,417 families adopted suggestions. In carrying out their work home-demonstration agents made 21,514 home visits at which they worked with 35,584 people. In all, 1,336,787 people were reached by the work of the agents.

ORGANIZATION.

In practically every State the membership of women in the county-extension organization increased, in several States as much as 50 per cent. The total membership reported up to December 2, 1920, was 83,936, the largest number, 23,722, being from Iowa.

Practically every State in the North and West has county organizations through which extension activities are carried on. Fundamental changes were made in the plan of organization in many States in order to admit on an equal basis all the people of the community and give to them all the rights and privileges of membership as well as a share in responsibilities assumed by the organization as well as in the work it proposed to do. In several States legislation has been specially modified to include home-demonstration work.

The program of work adopted was made broader in its scope to include such problems as the health and comfort of the family, the care of children, the convenience of the farm home, and the welfare of the rural community. Membership and county support increased last year, indicating that each State is meeting the needs of the people. The increase in funds in support of this work totaled \$221,777 more than the previous year.

PRINCIPAL LINES OF WORK.

All States in the North and West from which field records were received reported work in some phase of clothing, nutrition, and home management. Food preservation was a project in every State but one, health in all but two, while food production by women, and especially poultry improvement, were carried on in practically all the Central and Western States.

CLOTHING.

Work in clothing was carried on in 30 States with emphasis on the study of economy of time, effort, expense, and materials. The construction of dress forms from gummed paper, molded on the living model, was stressed in many States. Other phases of the clothing work are the fitting of foundation patterns to individual measurements, adaptation of commercial patterns, short cuts in sewing, the mastery of the sewing machine and its attachments, home hat making, and care and renovating of clothing. Forty-nine thousand four hundred and ninety-one garments were made or remodeled at a saving of \$203,789.

HEALTH AND SANITATION.

Agents worked closely with State boards of health, county boards, school boards, sanitary inspectors, health officers, doctors, nurses, and Red Cross officials. They have reported helping to crystallize the sentiment in their counties to the point of employing 76 county or community Red Cross nurses.

Improvement in the sanitary conditions of the farm home and premises has resulted from clean-up and fly campaigns, and general work in sanitation. The installation of 245 septic tanks is reported, while a large number of outdoor toilets were improved. Three hundred and sixty-two homes installed plumbing and 3,007 sinks were constructed. Sixteen thousand four hundred and seventeen homes are reported screened which had not previously had this protection. One county in Indiana conducted a rat and mouse campaign, in which thousands of these pests were exterminated.

Reports for 1920 indicate that the rural people are awakening to the need for concerted work along the line of personal and community health, and that the county-extension organization has been one of the main factors in securing the adoption of health practices and promoting the health point of view.

CHILD CARE AND FEEDING.

Reports of 1920 show a gradual but steadily increasing interest on the part of the women in studying child care and feeding. Five hundred and sixty-eight communities included this study in the program. Six hundred and eight communities studied child feeding, while 380

women carried on milk feeding demonstrations. In 1,899 communities women working with the home-demonstration agents promoted the serving of a hot dish at noon in 2,930 schools attended by 71,688 children. As a result of this work 15,822 children formed the habit of bringing milk to school for their noonday lunch; 8,859 children showed improvement in health; and 6,142 families reported having improved their methods of child care and feeding, which resulted in health improvement of 13,695 children.

The problem of determining the condition of the children in the neighborhood and of bringing those who were underweight up to the normal height-weight standard was a very concrete and practical piece of work undertaken last year in many communities under the guidance of the home-demonstration agent and the extension specialist, with the cooperation of local and State health authorities. In a number of counties one or more groups of children and parents were definitely used as demonstrations, which resulted in greater interest in proper food for children on the part of parents.

FOOD SELECTION.

It is not a long step from the definite work in child feeding to selecting properly balanced meals for the rest of the family. One thousand seven hundred and seventeen communities carried on work in food selection. The nutrition specialist for Illinois devised a "foods calendar," an instruction blank, by means of which home makers can determine whether they are serving well-selected food and what changes, if any, should be made. Meetings for local leaders were held by specialists and agents to give instructions in using the calendar, and these leaders returned to interest the women of their communities. During 1920, 6,000 Illinois women used the food calendar, about 80 per cent of them making changes in food selection as a consequence and reporting beneficial results. Most of the changes took the form of an increased use of vegetables, fruits, and milk.

On the whole, work in food selection in 1920 was more concrete and practical than ever before. Fifteen thousand seven hundred and eighty-four families were reported as making changes in food habits as a result of this work.

HOME MANAGEMENT.

Home-management work was carried on in practically every State. Household equipment has been one of the leading activities. Introducing running water into the farm home has been an outstanding activity in the central and eastern sections of the country. Five hundred and twenty-one families installed water systems in their homes as a result of home-demonstration work. Other phases of this project which received attention were house planning, furnishing, and remodeling, budgeting of time and money, keeping household accounts, cooperative purchasing of household supplies and textiles. The following home conveniences were reported installed: One thousand three hundred and twenty washing machines, 1,661 fireless cookers, 2,509 pressure or steam cookers, 641 driers, 1,009 power machines, 521 water systems, and 2,966 other conveniences.

FOOD PRODUCTION.

Poultry raising was the major project in food production. Gardening, cheese making, bee raising, and small fruits were projects in a few States. The management of the home flock has received special attention throughout the country. Some phase of this work has been carried on in 24 States and has been one of the projects whereby local leadership has functioned most fully and satisfactorily in the communities. Because of tangible results quickly obtained and their economic importance the work has made an appeal to both men and women. In the majority of States poultry work has been handled largely as a home project by the home-demonstration agents, the financial estimate of the poultry work done during 1920 being \$1,665,067.

While the reports for 1919 showed culling as the outstanding feature of poultry work, many records of the building of better houses, discarding poor flocks, securing better stock, improved feeding, establishment of breeding circles, and cooperative selling of eggs were included in last year's work. One State reported culled hens being sold in carload lots to commercial poultry men, and cooperative selling of eggs is also reported. Several poultry associations were formed. The program of work for 1921 in most of the States contains many long-time improvement poultry projects.

FOOD PRESERVATION.

The value of the pork, poultry, fish, meat, and eggs preserved by methods learned from extension workers and local leaders is reported as \$219,811 and the value of the fruits and vegetables as \$1,907,838. Food preservation is now being taught very largely by local leaders who have been trained by extension workers in past years. In several of the States specialists and agents gave local leaders who had this training short, intensive training courses at the beginning of the season. The women thus trained carried on the work of giving instruction to the other women of the community who needed help, and secured records of work done. The canning of meat and drying of vegetables and fruits received attention in some of the States, and brining was carried on as a minor project in 24 States.

COMMUNITY ENTERPRISES.

In community enterprises the bringing of rural people together to discuss a community program of work, based on community needs, has been the outstanding development. Every State reports an awakening of the individual to the responsibilities of the community. The chief activities developed have been community recreation centers, rest rooms, libraries, reading circles, tours for inspecting home equipment, and poultry, sewing rooms, fireless-cooker bees, day nurseries, and rest rooms at State and county fairs, hot school lunch, and groups organized for the purpose of buying cooperatively. The records of 1920 show a wide variety of materials purchased on the cooperative plan.

TRAINING OF THE ECONOMICS EXTENSION WORKERS.

Because of the increasing demand for well-trained home-economics extension workers, heads of home-economics departments of the land-grant colleges are assisting their students who are well qualified for this work to select courses in home economics, which include carefully chosen electives in agriculture, sociology, and economics, thus making their four-year college course fit them for entering the field of home-economics extension. Wisconsin, New York, and Minnesota offer such a four-year course, which includes a semester course in methods in home-economics extension work. Eight of the land-grant colleges in the Northern and Western States offered special courses for training home-economics workers in the summer of 1921, and others are planning to offer such courses in the summer of 1922. These courses are planned not only for seniors and graduate-college students, but for women trained in home economics who after graduation have had experience in home making or in home-economics teaching and who have the necessary personal and educational qualifications for extension work. It is from this group of mature women that the majority of home-demonstration agents are chosen.

OUTLOOK.

There is an increased interest among local people in home-demonstration work. It has been manifested in increased local appropriations for better office equipment, travel facilities, and larger appropriations for salaries. The present general policy of economy in legislative bodies is tending toward a conservative development of the work at this time, but with the coming of normal financial conditions it is confidently expected that there will be a sustained and rapid advance in the work.

BOYS' AND GIRLS' CLUB WORK.

During the year a State-club leader was employed in each of the 33 Northern and Western States, and on June 30 the rolls included also 52 assistant State-club leaders and 185 county-club agents, 148 of them on a full-time basis, part-time appointments having been confined to a very few of the States. Club work was also conducted in certain localities by county agricultural agents and home-demonstration agents, and the figures received from the States were used in a comparison of the accomplishments under the three types of leadership.

The 1,200 county agricultural agents who were engaged in club activities reported a total enrollment of 72,758, with 54 per cent of that number completing the prescribed work, or an average of 60 enrollments per agent with 33 members completing.

Under the home-demonstration agents, of which there were 250, 14,772 boys and girls were enrolled, with 47 per cent of them carrying their demonstrations to a close, or for the individual agent, 59 members with 28 finishing.

In 148 counties with county-club agents there was an enrollment of 65,371, or an average per county of 441 young people. The number completing per county-club agent was 296, or 67 per cent.

The total enrollment secured under all three forms of organization was 216,479, with 59 per cent of that number complying with all the rules set forth for club members.

ORGANIZATION.

Boys' and girls' club work is practically an integral part of the county-extension organization throughout the North and West. This is evidenced by the fact that in 686 out of the entire 1,500 counties there is an agreement which provides that the young people may hold membership, and that 1,403 project leaders of the county-extension organizations are assisting in the supervision of the demonstrations with boys and girls. The specialist also takes much interest in the work, 140 of them having devoted part of their time to the training of local leaders and the preparation of subject-matter material. In conducting the club work with 216,479 juniors, the State and assistant State club leaders, with the county-club agents, developed 1,604 community programs of work and held 1,271 county and local training conferences for club leaders, with an attendance of 14,429.

RESULTS.

The demonstrations carried on by the club members during the year 1920 were more specific in character, as shown in the club activities conducted.

In the corn clubs there was an enrollment of 6,368, of which number 3,009 completed the work and produced 243,319 bushels of corn, valued at \$188,748. There were 2,145 demonstrations in seed selection, 1,756 in seed storing, 1,699 in seed testing, and 2,011 in better methods of cultivation. Reports indicate that these demonstrations affected the corn-growing practices on more than 6,000 farms.

An enrollment of 7,787 is reported in the potato-club work, with 4,183 completing the work and a production valued at \$196,494. The young people conducted 1,015 demonstrations in hill selection, 1,407 in the keeping of seed, 1,931 in spraying, and 627 in grading for market. The methods on more than 7,000 farms were improved.

There were 75,205 members in the garden clubs, 45,890 of whom carried their work through the club year with a production valued at \$555,460. They conducted 21,750 demonstrations in spraying and 3,723 in the testing of seed. In addition, 6,297 irrigation demonstrations were conducted in the dry Western States, where the maintenance of home gardens throughout the productive season has been a real problem.

In the sow-and-litter phase of the pig-club demonstration, there was a total enrollment of 6,853, with 4,672 completing. The value given for pigs raised was \$1,124,926. There were 3,035 demonstrations in the introduction of purebred stock and 2,923 in improved methods of feeding. Reports indicate that over 7,000 farms were benefited.

In the pork production and breeding phases of the pig-club work 14,672 members were enrolled, of which 9,550 reported having managed 19,461 animals and produced 1,896,561 pounds of pork, at a

valuation of \$406,913. The demonstrations in the feeding of purebred stock totaled 4,251, those in the use of pasturage with grain 2,931, those in the use of protein supplement in rations 3,085, and 397 in the home-killing and curing of pork, reaching the practices on 16,000 farms.

In the dairy-calf projects there was an enrollment of 5,068, with 2,768 members finishing. The young people reared stock valued at \$434,286. They conducted 1,300 demonstrations in the introduction of purebred live stock, and 1,637 in improved methods of feeding.

The dairy-heifer clubs seem to be of increasing importance. They reported an enrollment of 1,398, with 1,156 completions. The animals owned by the young people were valued at \$211,218. There were 458 demonstrations in the introduction of purebred stock, 475 in improved methods of feeding, and 328 in the use of purebred sires, resulting in improving the practices on 1,600 farms.

There were 356 members in the cow-and-calf clubs, 332 of them going through with their work to the close of the year. Demonstrations were conducted in the weighing of milk, testing for butter fat, use of economically balanced rations, use of purebred sires, and the feeding of calves.

The baby-beef clubs had 2,515 members enrolled, 1,968 of whom finished all work and managed 2,066 animals. Demonstrations in the selection of individuals and the use of purebred sires were conducted by practically all of these young people.

Sheep-club enrollment totaled 2,333 boys and girls. Of this number, 1,121 reported that they had kept 3,959 sheep, raised 3,624 lambs, and produced 24,263 pounds of wool (sheared), and that the total value of their sheep, lambs, and wool produced aggregated \$66,517. They conducted demonstrations in the culling of flocks before breeding, the use of purebred rams, the winter care and management of the animals, better preparation for wool shearing, and in prevention and control of stomach worms.

In the poultry-club work 17,213 boys and girls were enrolled, with 8,185 of them finishing the work. They produced poultry valued at \$345,218 and conducted demonstrations in culling, in the introduction of better stock, in feeding for egg production, in early hatching, in the production of infertile eggs, and in proper housing and the control of parasites.

There were 23,832 canning-club members who reported 665,418 quarts of meats, vegetables, fruits, and soups, and 73,962 glasses of jellies, jams, and preserves. They conducted 11,912 demonstrations in the canning of vegetables, 3,000 in the canning of meats, 1,000 in the use of tin cans, 1,500 in the use of the pressure cooker, and 300 in the marketing of home-canned products. It was estimated that the practices in 30,000 homes were improved.

The bread clubs reported an enrollment of 8,470. These young people made 311,016 loaves of bread, 18,807 dozen quickbreads, and 36,284 other baked foods. In addition 4,000 of these club girls did all the family baking, showing a net saving in their own homes of \$17,433. There were 5,000 demonstrations in the use of desirable yeast, 5,000 in improved methods of bread making, and 800 in the care of bread. The reports show that over 10,000 homes were benefited.

There was a membership of 5,877 in the meal-preparation clubs. Of this number 3,006 reported having prepared 27,300 meals, baked 18,753 loaves of bread, and prepared for the table a total of 213,554 foods. Through the work in the club activity nearly 6,000 club boys and girls have learned and are able to explain in their public demonstrations the simple, fundamental principles of food selection and why some foods are especially important in the diet. During 1920 nearly a thousand of the club members enrolled, demonstrated the use and value of milk products, and an equal number the planning and serving of meals.

In the hot-school-lunch clubs there were 3,702 members, of whom 2,532 reported having prepared 230,800 lunches. They gave 4,000 demonstrations in the use of milk and milk products, 2,500 in planning of meals, 3,000 in preparation of food, and 1,200 in the care of food. During 1920 a considerable increase was noted in the number of schools establishing permanent facilities for carrying on the hot lunch as a result of the successful work done by hot-lunch clubs.

The clothing clubs enrolled 29,228 members, of whom 59 per cent produced garments valued at \$122,332. They gave 5,000 demonstrations in the keeping of clothing costs, 8,000 in the use of the sewing machine, 5,000 in the making of simple, durable underwear, 1,500 in remaking and caring for clothing, and 250 in the trimming of hats. Practically all clothing-club girls did their own mending and 2,848 kept the clothing of the entire family in order. Short cuts in sewing were emphasized, especially in clubs of older girls. Throughout the North and West club girls showed a keen interest in demonstrating the essentials of appropriate dress. As a consequence the girls are learning and demonstrating as well, correct standards of dress in relation to health, personal appearance, and occasion; how to judge the value of well-made garments and how to exercise economy in buying.

That boys and girls, through the home-making clubs, are gaining a fuller appreciation of rural home life is proved in the large increase of home-making activities reported and work accomplished during 1920. Through the spirit of free wholesome play common to all club work, much of the drudgery of the home is being converted into pleasurable tasks. Through the organized club group in which members can discuss freely their problems, they are gaining a broad intelligent viewpoint toward rural home making. Through the public demonstration team, they are successfully demonstrating the worth-while practices learned in their club work to the home makers of the community. Thus boys and girls' club work is playing a large part in rural home development.

In carrying out this program there were 8,391 volunteer local leaders and to stimulate interest in the work the agricultural colleges offered 730 scholarships, and also conducted short courses for 3,383 boys and girls. In 1920 there were over 1,800 former club members in attendance at the various agricultural colleges with the intention of completing the regular four-year course in either agriculture or home economics.

In order to conduct this work the young people borrowed \$883,721 from the banks of the country and met their obligations in a busi-

nesslike way, repaying the entire amount. The total value of products resulting from all demonstrations was \$4,621,538.

While these figures indicate that the club boys and girls have developed a business of considerable proportions, the greatest benefit of the work has come from its helpful influence in demonstrating that through such work rural life can be made attractive as well as profitable and a superior citizenship can be built up among American farmers.

OUTLOOK.

The widespread depression in the value of farm products and the general movement for economy throughout the country has slackened the demand for county club agents. The effect of this depression upon the growth of boys and girls' club work has been most evident in the Western States, especially in the semiarid sections, where crops failures have occurred for the last three or four years.

The development of the work from contests, exhibits, and judging into real demonstrations has attracted the attention of practical and progressive men and women of the rural communities who as leaders are giving their time and energy to club direction. In many counties where it was necessary, owing to financial losses to curtail expenditures for extension activities, the people of the communities have voluntarily carried on the work, so that it might again be taken up by paid leadership when there is an improved market for farm products. Future development, however, will be determined by the character and quality of the leadership employed, and judging from the progress that has been made in methods and plans the indications are that greater and more substantial results can be expected from this type of work during the next few years.

FARM-MANAGEMENT DEMONSTRATIONS.

Twenty-seven of the 33 Northern and Western States had farm-management demonstrators during the year 1920-21. Nine of these States employed more than one man in this line of work. The farm-management demonstration work has been vitalized during the year by the keener interest which both farmers and county agents have been taking in economical production and the business side of farming, and the special assistance given by the Office of Farm Management of this department in preparing literature and statistical digests of economic value for the use of the farm-management demonstrators and county agents.

ACCOUNTING SCHOOLS.

The activities of the demonstrators have shifted rapidly from work with individual farmers to work with groups of farmers. The perfecting of the county extension organizations has made possible this change. This year 860 farm-accounting schools with an attendance of 19,744 were held, as compared with 486 schools with an attendance of 9,980 the previous year. A total of 1,005 general farm-management meetings attended by 53,978 people were held, as compared with 1,187 meetings with an attendance of 37,342 last year. The change in meetings held has been essentially that of changing from

the general meetings of one session to the full-day farm-accounting meetings. This means that in addition to the training in account keeping the meetings also include the discussion of subject matter similar to that given in the general meetings.

Farm accounting continues an important basis of extension teaching in farm management. The call for simple farm-account books resulted in the distribution of upwards of 200,000 books. Bankers, State farm-bureau federations, other institutions, and local farmer leaders have been instrumental in assisting the county agents and the demonstrators in distributing farm-account books to interested farmers and in helping farmers to keep and summarize their records. During the year 441 county agents reported assisting 11,007 farmers in summarizing and analyzing their accounts, while 209 report that 3,213 farmers made profitable changes in their business as a result of keeping such accounts.

DEFINITE AREAS ESTABLISHED.

A development of special note has been the establishment of a few definite areas of work where it is planned to secure records from the same group of 40 or more farmers over successive years. This is an intensive type of work which is proving its merit in depicting the outstanding agricultural problems of the community and in demonstrating the factors influencing the successful organization and management of farms under local conditions.

Other lines of work which have been undertaken and which have given good results include such matters as meetings to discuss farm tenancy, farm-management exhibits, accounting work with boys and girls, and enterprise cost-accounting work taken up by many farmers.

Several State agricultural colleges have established or reorganized their farm-management departments during the year looking toward stronger teaching courses in this subject and greater aid to the farm-management demonstration work. While accounting work in one form or another with a digest and analysis of the data thus attained continues to constitute the bulk of the work of the farm-management demonstrators, the work is expanding in a substantial way to include a presentation to farmers of the broader facts of rural economics as well.

EXTENSION SPECIALISTS.

The work of extension specialists connected with the State agricultural colleges was more closely related during the year to the plans and programs of work of county agents; and while there was apparently a numerical decrease in the number of demonstrations given, there was actually an increase in that method of teaching. There has been a gradual increase in the number of well-defined lines of work carried by specialists in cooperation with county agents. The services of the specialist along such lines as fruit growing, poultry raising, plant pathology, insect control, rodent control, and marketing, have been increasing in demand by county agents and by other members of county extension forces. Methods of improving

the quality of seed stock, promotion of more intensive growing of legumes, development of interest in purebred sires, and introduction of the most advanced methods of marketing fruit have been given particular attention by the specialists from the extension division of the agricultural college.

PLANS OF WORK.

Plans of work covering the various agricultural enterprises of a county have, in a large measure, been determined and shaped by the extension specialists from the college in the annual conference of extension workers.

Much more care was given this year than previously to the keeping of subject-matter records, thus preventing great losses being caused by the inability of a new specialist to take up the work of a predecessor. The extension specialist has occupied the position of intermediary between the farmer and the county agent (who are from time to time learning of certain problems requiring investigational work) and the State experiment station.

There was no great change in the personnel of extension specialists, as was the case in the previous year, and this stability contributed to the continuity and success of the work both at the institution and in the counties.

In lines of work in which the subject matter overlaps to any great degree there is an ever-increasing cooperation on the part of the specialists, and this develops the related lines of work more as a unit.

Specialists have in many instances given particular attention to determining the measure of results of the year's work. These measures are not always determined by increased yields in one year, but more by the general acceptance of a practice throughout a region having common agricultural problems. Many specialists, in order to develop certain fundamental principles, have zealously studied the extension method of teaching adults.

SPECIALISTS FROM OTHER BUREAUS.

A number of bureaus of the department are employing persons whose chief interest is the extension of the department's information to the States, and in many instances these men cooperate with the States Relations Service in studying extension matter, organization within a State, and methods of extending the teaching of both the agricultural colleges and the United States Department of Agriculture. Such specialists were employed by the Bureaus of Animal Industry, Plant Industry, Public Roads, Biological Survey, and Markets. Several other specialists within the department, who are engaged in investigational work are, through informal conferences, assisting in the extension of results of their investigations.

WEEKLY CONFERENCES.

The weekly conferences of the department's extension specialists have been continued through their fourth year for the purpose of bringing about a clearer understanding as to extension problems, to discuss extension methods and to consider various ways of carrying results of investigational work of the department to the States. Oc-

asionally these conferences have been held in different bureaus in order that a clearer understanding might be acquired of the relations of work investigated and extended. Through these conferences there has been brought about a better understanding among the department's extension workers, and more efficient cooperation has developed.

OFFICE OF HOME ECONOMICS.

C. F. LANGWORTHY, *Chief.*

Housekeeping involves many processes, uses many different materials, and requires much time and labor. Knowledge and skill are important elements of success. Economy of time, of labor, and of materials are all important in making the family resources meet the family needs. The Office of Home Economics has kept these facts in mind not only in the gathering and summarizing of information on a wide range of home problems, but also in the planning and carrying out of experimental studies.

In general, the kinds of work have followed the same lines as in previous years, with such additions as resources have permitted. Problems of relative food value and food selection, meal planning, food needs of children, special studies of cooking and canning processes and of the relative efficiency and the possibilities of improvement in the use of different fuels in food preparation have made up a large part of the work. It is natural that this should be the case, since information regarding the rational use of our varied food supply is of prime importance from the standpoint of health, comfort, and economy. With available resources it has not been possible to carry on extensive studies in the selection, repair, and care of clothing and household equipment, or to undertake surveys or other field work needed to meet the increasing demand for information on home problems. In so far as possible, however, subject matter has been collected, classified, and digested and sent out in response to requests from housekeepers, extension workers, and various agencies having to do with the use of agricultural products and methods of saving labor in the household.

In all this work the Office of Home Economics has continued its policy of cooperation with other bureaus of the department and other Government agencies; and the specialized methods of research used in this office and the designs for special laboratory equipment, including particularly the respiration calorimeters and that in the experimental kitchen, have proved of great service to other investigators.

The experimental kitchen continued its studies of research methods in cooperation with home-economics workers in agricultural colleges and elsewhere with a view to standardizing procedure and thus insuring comparable results. In this it has given preference to problems suggested by extension workers, as they have direct contact with the farm woman and a knowledge of the problems that especially interest her. The projects undertaken in this laboratory may be briefly summarized as follows:

For the purpose of determining whether the observed differences in the culinary quality of granulated and smooth fats, or of hard and soft fats, are attributable to the physical character, investigations were undertaken in cooperation with the Bureau of Standards. Of several methods tried, one for

determining plasticity, developed for a very different purpose, was experimented with and adapted to the study of this problem. The results obtained are of interest and value, not only from the standpoint of the physicist or technologist who may be interested in plasticity determinations of fats and greases, but also from the standpoint of the Federal inspector and of the housewife who buys these materials.

The studies in pastry making have been continued and many facts of practical value to the housewife discovered. For instance, it has been shown that the recipe used, the method of mixing and handling the dough, and the baking temperature affect the quality of the crust far more than does the kind of fat. The effect of temperature at time of mixing, on the various ingredients of the dough, has been studied; the effect of using pans of different kinds of material in pastry baking has also been observed; and experiments on different kinds of flour have been begun. Different methods of preventing soaking of the under crust of custard and berry pies have been compared.

The studies of canning by home methods have been continued, and on the basis of the data so obtained, together with the recorded field experience of extension workers, teachers, and housekeepers, and the statistical evidence available, a Farmers' Bulletin was prepared.

Tests have been made with corn, spinach, string beans, lima beans, asparagus, and peas, to which lemon juice and vinegar were added in proportions ranging from 1 to 4 tablespoons per quart jar. The time of processing was materially less than that required when no acid was added. Though not always detected when only 1 tablespoon of lemon juice or vinegar was used, the acid taste was usually noticeable, but it could be greatly modified by skillful seasoning and by careful methods of cooking; and these products proved to be acceptable to the average person. Except for a slight toughening of the skins of mature lima beans and peas, neither lemon juice nor vinegar (in the amounts here designated) seemed to have any effect on the texture of the canned vegetables. Formulae have been derived which indicate the amount and kind of acid to be used with each vegetable.

Studies were made of the bacterial flora of 938 cans of vegetables processed by home methods in both glass jars and tin cans. Most of these vegetables, which included corn, peas, lima beans, string beans, asparagus, spinach, chard, okra, field peas, carrots, summer squash, and tomatoes, were canned in the Office of Home Economics, but a number were canned under home conditions in other localities. The bacteriological examination showed that home-canned vegetables in first-class condition are not necessarily sterile, and that they frequently contain spores of resistant bacteria. These organisms, however, do not cause spoilage, provided the can has a good vacuum and the seal remains tight. Living vegetative bacteria were not found in the cans with the contents in good condition, but they were present in the vegetables in leaky containers. The most frequent cause of spoilage in these home-canned vegetables appears to be the presence of a group of anaerobic butyric acid bacteria, which are apparently capable of withstanding any practicable method of processing in which the temperature does not go over 100° C.

The relation of closeness of pack to heat penetration and hence to the time required for processing, led to a comparative study of a mixture of several kinds of vegetables packed more or less closely together as compared with a single sort similarly packed. Judged by the results obtained, combinations generally packed more closely than the same vegetables alone, though this is not necessarily the case. The shapes and the relative sizes of the vegetables and the proportion of each in the mixture must be taken into account, and also the method of packing. For instance, succotash containing a considerable proportion of string beans or large lima beans may require less time for satisfactory processing than would corn or even lima beans alone.

In a comparison of methods, a bath having a temperature higher than that of boiling water was used for processing canned vegetables. A solution of 1 part of common salt in 2 parts of water by weight used for the bath produced a temperature practically the same as that of steam under 5 pounds pressure. In this case from one-third to one-half less time was required for the processing than is required in the ordinary water bath. This method is not entirely satisfactory when canning in glass, because all the liquid evaporates from the jars; but it seems to give satisfactory results when tin cans are used.

Studies were made of the rate of heat penetration into different vegetables packed in the quart glass jar, when processed in a boiling water bath. Varying

the initial temperature of the contents of the jar (e. g., by cold dipping) had little or no effect upon the time required to reach retort temperature, except in case of those vegetables which, like sweet potatoes, tightly packed, spinach, and corn packed in a semisolid starchy mass (Maine style), are heated mainly by conduction rather than by convection. Studies were also made of the effect of closeness of pack upon the time-temperature curve of the contents at the center of the jar.

Data were compiled showing percentages of spoilage of about 2,000 cans or jars of vegetables when all the various current home methods of processing were used.

Since the pressure cooker has proved its value in home canning, it has seemed wise to test its practicability in cooking vegetables, meats, chicken, puddings, brown bread, and other foods, and to work out standardized methods. The time of cooking is, of course, greatly decreased as compared with that required by ordinary ways, and some foods seem to have a superior texture and flavor when cooked by this method.

Methods of extracting juice for jelly making were studied, using a considerable variety of fruits, including, among others, apples, crab apples, Japan and garden quinces, pears, berries, grapes, citrus fruits, and rhubarb. The juice of the Japan quince, the well-known ornamental shrub, was found to be highly flavored and very rich in pectin and acid and hence excellent for combination with certain other fruit juices lacking these characteristics. A satisfactory jelly was obtained from fruit juice lacking in pectin when 4 tablespoonfuls of a homemade apple pectin sirup were used to a cup of the juice. The aromatic fruits of the "trifoliate" orange tree (a variety hardy in Washington) were successfully used for flavoring a fruit pomace used for making jam.

Tests were continued with the making of pectin sirup from different varieties of apples, and the results of this and earlier work were summarized for the use of extension workers. The study of methods of making and utilizing pectin from citrus-fruit peelings is being continued.

As a result of many comparative tests, recipes were developed for making candied citrus-fruit-peel confections and for a short-process citrus-fruit marmalade.

Some studies were undertaken at the request of the Bureau of Plant Industry on the possibility of sprouting and cooking mung beans. This method of increasing the vitamine content of the diet by sprouting seeds has long been practiced empirically in the Orient and was used to advantage in the case of some of the expeditionary forces during the war. Experiments were accordingly undertaken with a view to determine whether or not such a procedure would be practicable in American homes. The products so prepared and cooked were palatable, but the chief difficulty is to develop the sprouts to the requisite size and degree of tenderness in large quantity, without the occurrence of mold or fermentation. Progress was made with respect to this detail.

Experiments showed that when using a certain very widely employed formula and method of manipulation boiled custard can be considered "done" when the temperature reaches a definite point; and that this temperature varies with the kind and amount of sugar used to sweeten the custard, other things being equal.

Measurements of the internal temperatures attained within food materials, especially vegetables, during cooking were begun. Studies were made on potatoes, carrots, cabbage, peas, and beets. The information obtained is intended as a contribution to the discussion of the destruction of vitamines by cooking processes. From the work done so far it appears that potatoes boiled whole are completely cooked shortly before the center reaches the temperature of boiling water; that cabbage ribs, on the other hand, have to remain at 100° C. for about 25 minutes before they are cooked.

At the request of the Bureau of Animal Industry and of the Bureau of Markets some tests were made of the relative economy, flavor, and culinary quality of different grades and classes of meat cooked by standardized methods. The cooking qualities of soft pork products from peanut-fed hogs, in comparison with the usual grades of pork, have been tested to some extent, but the data obtained are not as yet sufficient for generalization. Some studies were also made of the merits of various home methods of corning beef, judged by the quality of the product and the length of time it will keep.

Experimental work with bottle yeast made with potatoes was continued. Fresh supplies can be made readily from ordinary yeast cakes, and the yeast keeps well at room temperature (75° to 100° F.), provided the culture ("sponge") be renewed every two or three days. Such yeast may prove a con-

venience to housekeepers who do not have refrigerators or other cooling devices to keep fresh yeast in good condition or who can not conveniently obtain it.

A study of the variations in the weight of a teaspoon of baking powder was summarized for the use of extension workers and other teachers. This is a matter of interest when great exactness is sought in cookery or where comparative costs of different brands are to be considered.

In continuation of studies of energy expenditure in household tasks, carried on under definite and controlled conditions in the respiration calorimeter laboratory, the energy requirements for sewing were given special consideration. The object was to determine the increase, if any, in energy expenditure in sewing on heavy-weight goods as compared with light-weight; the energy expenditure in sewing at different speeds; and the energy expenditure of a woman sewing by hand, with a foot-driven sewing machine, and with a motor-driven machine. In sewing with the power-driven machine and by hand the subject expended about the same amount of energy per hour, but sixteen times more work was accomplished with the motor-driven machine. The energy expended per hour for the work done with the foot-driven machine was about six times as great as in the case of hand sewing, but the output was fourteen times greater.

The respiration calorimeter, in addition to its value for studying problems of household labor, has proved itself to be an instrument of precision for the study of many agricultural problems involving heat production and oxidation, such as occur in ripening fruit, and work of this kind was continued. The experiments of this sort on vegetables and fruits have for their object the determination of the nature and extent of these changes and their control, and the results will find their application in insuring greater efficiency in farm and commercial storage operations.

Nontechnical methods of teaching food selection, meal planning, and other phases of practical dietetics continued to be an important feature of the work of the office. Methods of estimating the food value of diets were devised and published. A set of eight pictorial charts on food selection and meal planning and a Farmers' Bulletin describing them have also been issued. These charts take into account the quantity and also the kinds of food needed in the diet of the average family or individual. They are based on the classification of food into the five following characteristic groups: Vegetables and fruits; milk, eggs, meat, and other efficient protein foods; cereals and the products made from them; sugar and other sweets; and butter, table oils, and other fat-rich foods. The relation of this work to the farm home is particularly evident from the importance laid on dairy products and vegetables and fruits from the home garden.

A number of studies of problems pertaining to the care and repair of household equipment were made, such as the relative value of different cements and adhesives for mending china, glass, wood, and other materials, the preparation and finish of wood, and the cleaning and repair of carpets and rugs. A special study of the relative value of three floor oils was made with respect to the durability of the gloss and the color of the floor.

On the basis of data gathered in a survey previously made in farm homes, a paper entitled "A Survey of Farm Homes" was published. It discusses such questions as the amount, character, and the distribution of home labor, the health of members of the household, the

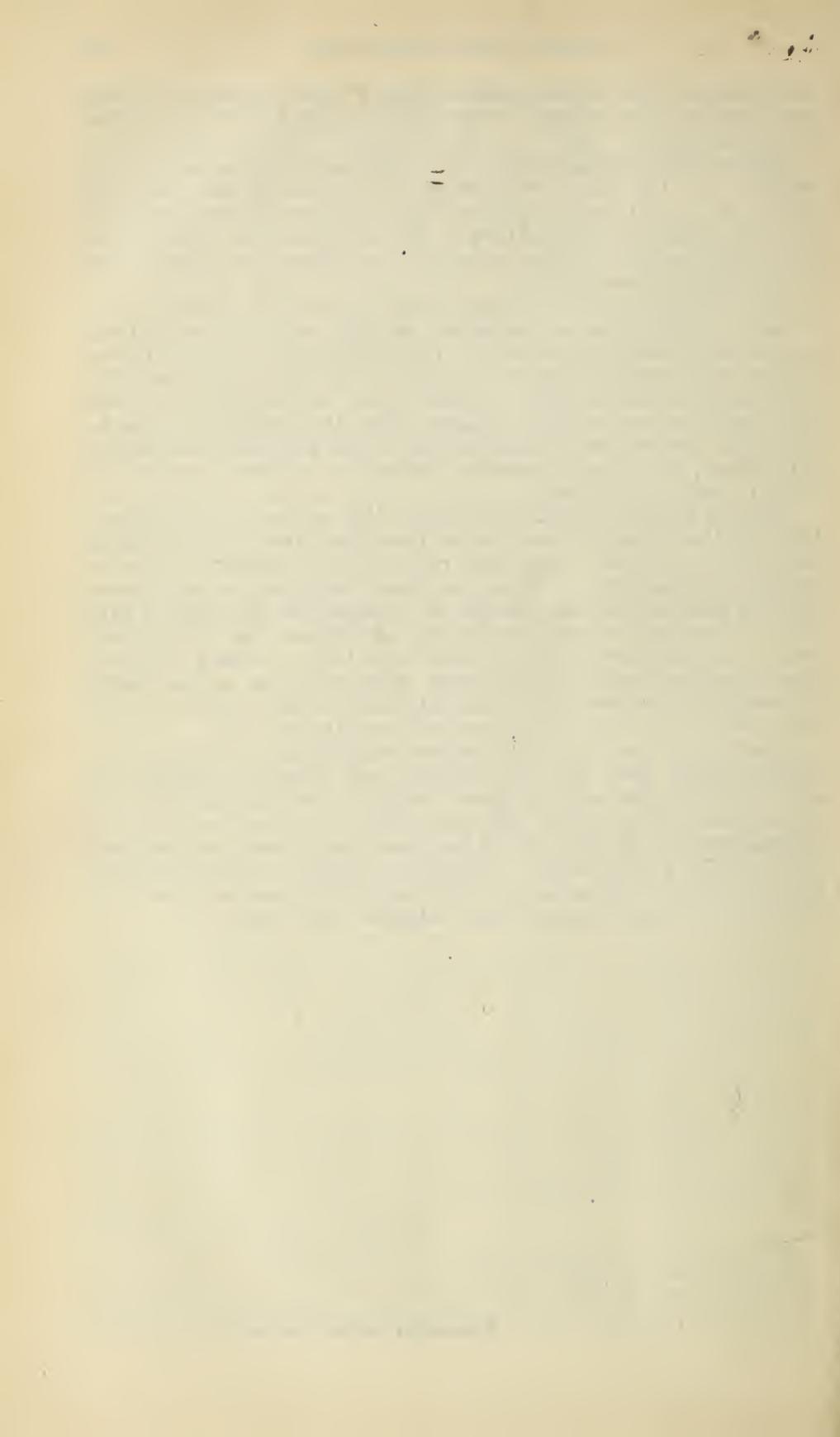
contribution of the wife's income derived from poultry and dairy products, and the relation of home and family life to that of the community.

Material from another survey was used in the preparation of a bulletin on "The Labor and Leisure Year of the Farmer and His Wife" as a joint project of the Office of Farm Management and Farm Economics and the Office of Home Economics. Plans have been made for the further cooperation of these two offices in an intensive farm-home survey.

As in former years, an important part of the work was the preparation for publication of bulletins, circulars, and articles of both popular and technical character. The shortage of funds for printing technical material especially made it necessary to continue the publication of such articles in professional and technical journals and thus give to the public without delay the results of research. Since 1917, 36 articles of this kind have been published outside the department, 10 of these appearing during the last fiscal year, while 13 more await publication.

Two new Farmers' Bulletins, entitled "Rice as Food" and "House-cleaning Made Easier," prepared in this office, were printed during the year; several older ones were revised, and six others were submitted for publication. "Food for Farm Families," an article embodying some of the data collected in a dietary survey made by this office in cooperation with the Bureau of Markets and Crop Estimates, was published in the Yearbook for 1920. About a hundred short, popular articles giving timely information on a wide range of household problems were contributed to the Press Service of the department for use in newspapers and periodicals.

Summaries of work in the experimental kitchen were sent out in mimeographed form to both extension and research workers and subject matter for mimeographed circulars were supplied to the other offices of the service. In cooperation with the Treasury Department and the Federal Board for Vocational Education, the office responded to a request for a program outlining for housekeepers practical ways of organizing the business of the household so as to make the best use of money, time, materials, and labor.



DEPARTMENT OF THE
STATES RELATIONS SERVICE
DEC 13 1921
EXPERIMENT STATION FILE

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REPORT OF THE CHIEF OF THE WEATHER BUREAU.

UNITED STATES DEPARTMENT OF AGRICULTURE,
WEATHER BUREAU,
Washington, D. C., October 11, 1921.

SIR: I have the honor to submit herewith a report of the operations of the Weather Bureau during the fiscal year ended June 30, 1921.

Respectfully,

C. F. MARVIN,
Chief of Bureau.

Hon. HENRY C. WALLACE,
Secretary of Agriculture.

No material change has occurred in the customary annual program of the work of the Bureau except that some additional curtailments and omissions of service have been entailed from the continued high costs and charges which must be met from appropriations remaining the same as in pre-war times.

The serious difficulties encountered in maintaining and recruiting the personnel of the service have somewhat abated. At the close of the year the number of temporary and untrained employees carried on the rolls without civil-service status, pending the certification of eligibles, had been reduced to 72. However, comparatively few young men in the country with the qualifications and abilities required for the grade of assistant observer seem attracted by the low entrance salaries (\$1,080 with bonus of \$240) and the poor opportunities of progress and advancement still characterizing Government position in the Weather Bureau. The registers of eligibles secured as a result of the several civil-service examinations which have been held have been rapidly exhausted in effecting replacements of temporary appointees by probationers willing to accept the positions and assignments tendered.

The success of the Weather Bureau and the economic benefits flowing from its service and warnings depend in a peculiar and extreme degree upon its man power—upon the technical experience and ability of its personnel. Professional meteorologists and forecasters can not be secured from the universities or from the outside. The Bureau itself is the only possible training school for the future leaders in the service.

The long-promised and long-delayed reclassification of Government salaries is nowhere more greatly needed or justified than in the Weather Bureau. The imaginary economies in withholding urgently-needed increases for properly strengthening and recruiting the personnel is not economy, but sap and injure the vitality of the organi-

zation and is certain to be reflected in future inferiority and inefficiency. Another legislative year should not go by without some concrete congressional enactment making the promised reclassification effective.

The new demands upon the Bureau for its services and advices in aid of aviation; for data and the certification of facts with reference to storm, weather, and rain insurance; for reports on the influence of weather upon the public highways; for extensions of its various services in reporting frosts, cold waves, hurricanes, etc.—all continue to be pressed urgently by the diverse interests involved. Even under the present national exigencies compelling the utmost economies in Government appropriations, it is intended to urge upon Congress, through the Director of the Budget, certain very necessary increases to enable the Bureau to meet its reasonable obligations and responsibilities to the public with reference to the most urgent needs. It is easy to show that Weather Bureau service and advices carry with them, in a very great degree, an immediate and direct economic benefit in the saving of the lives, properties, and foodstuffs of the Nation. Many shocking accidents in aeronautics have resulted very directly from lack of sufficient foreknowledge of flying-weather conditions along the customary airways. The Weather Bureau is the agency charged by law to perform this new service, and a skeleton organization is now in operation. However, the funds available suffice to provide only a fraction of the stations, reports, and advices needed to represent conditions over such a great extent of territory as the United States.

Hurricanes and violent storms of the tropical oceans bring losses and disasters to shipping of the Gulf, and alarm and consternation to the residents of the whole Gulf coast. At such times the Weather Bureau at Washington, and its field stations in the menaced region, are literally overwhelmed with direct and indirect applications for information. Its warnings and advices allay the fears of some, quiet needless alarm of others, and guide many to make timely escapes from almost certain death in threatened localities, or to take precautions to minimize the destructive effects of a storm which can not be escaped.

Vessels while still at sea now receive, often days beforehand, warnings which are broadcast daily by wireless, and thus are easily able to shun the danger zone and probably escape injury or wreck.

Warnings of frosts, cold waves, blizzards, and weather conditions damaging to perishable foodstuffs in shipment are other important services of the Bureau showing an immediate beneficial or monetary return and saving. These are all services which can not be curtailed or abridged without great public detriment and even loss of life and property.

Even under the present program of economy a reasonable support of this work is justified and will be rewarded.

FORECAST SERVICE.

Only three tropical storms occurred within this fiscal year, two in the closing six months of 1920 and one striking the Texas coast on June 22, 1921. Fortunately, none of these was notably severe or accompanied by marked losses of life and property.

It is important to recognize, however, that because of the very meager reports available, little idea of the severity and destructiveness of these great storms can be formed while they are far at sea. These characteristics are disclosed only after the storm passes inland. On the other hand, the broadcasting of warnings and advices merely reporting the existence of such a storm at once awakens the fears and apprehension of the public which are fully allayed only after the final report of the dissipation of the storm or its passage beyond our territories.

It seems quite pertinent to this question to make a few quotations from newspaper editorials commenting on the beneficial service of the Weather Bureau with special reference to the hurricane of September 21, 1920.

AHEAD OF THE HURRICANE.

The storm now beating against our southern coast did not come as a surprise. Two days ago the Weather Bureau gave public warning of the hurricane's approach and was able, within fairly narrow limits, to tell where and when it would strike and what force would be back of the blow. Probably the shipping saved in this one tornado is greater in value than the cost of the Weather Bureau for years, and one does not like to fix a money value on the great saving of life.—*Chicago Evening Journal*, September 22, 1920.

VALUE OF WEATHER BUREAU ATTESTED.

The importance and value of the United States Weather Bureau service was unmistakably and impressively attested in connection with the terrific storm which on Tuesday night swept up from the Gulf of Mexico and struck the coast of the United States, particularly across Louisiana. Hours before the hurricane had reached the mainland the weather official knew it was coming. Warnings were hurriedly sent out, not only to the shipping in the Gulf but to the cities, towns, and farms over the section that was threatened. As a result of the warnings, ships and especially the smaller craft out in the open scurried to shelter. Boats that were ready to sail remained in port. On land as well preparations were made to meet the storm. Shelters were constructed, insecure movables were fastened down, trains were given added protection—in short, every possible precaution was taken to withstand the rage of the elements when it should break.

As a result of these preparations it is estimated that many lives were saved and much property loss prevented. The storm came in its fury and much damage was done; for it is not within the ability of man to shield completely the open fields and their crops, his homes, and other possessions from torrential storm and hurricane. But when the violence had abated and a survey of the damage brought realization of what might have been suffered had the storm come unannounced there could not but be universal gratitude and appreciation of the ability of the weather service to forecast the future and send out its beneficial warning.—*Salt Lake Desert News*, September 23, 1920.

A MILD HURRICANE.

The hurricane of this year did not prove as severe as many of its predecessors and the damage was comparatively small. This is partly due to the fact that residents along the coast have been fully educated to the danger of the hurricane and now adopt the sensible plan of getting out of the danger zone as much as possible and protecting their property as well as they can. There is small profit and little sense in the effort by a human being to fight a hurricane. Because of the precautions taken and through the additional fact that the storm was not as severe as has been known in other years, the country escaped with a minimum amount of damage and loss of life.

It must be said for the Weather Bureau in connection with the work of forecasting this storm that it performed most admirable and valuable service. To predict when and where a West Indian hurricane will arrive at a given point and estimate with any degree of accuracy the condition in which it will arrive

is no easy task. Indeed, there are times when the undertaking is simply impossible. There are no observation stations in the middle of the Gulf of Mexico and, lacking these, the Weather Bureau is sorely handicapped by the lack of necessary information.

On this storm, however, the Bureau made a most excellent record. It reported its appearance in the western Caribbean Sea and estimated the time of its approach as closely as could possibly be done.—*San Antonio Daily Light*, September 23, 1920.

DETECTION OF THE STORM.

That the tropical storm (Sept. 22, 1920) that was detected by the United States Weather Bureau 500 or more miles out at sea spent its fury before coming inland is not the important point. Detection of the storm by the Bureau and the ability of the Bureau to give the threatened sections of the country information in advance of its coming is the paramount detail. The service rendered slipping at sea and life and property on shore through the timely warnings issued by the Bureau may never be estimated. The Weather Bureau has made impossible occurrences of the past when ships went forth to be caught unaware in the teeth of a hurricane and when people ashore slept in fancied security from the coming of blast and flood that wreck property and destroy lives. In this instance hundreds of ships were held safely in port while people were enabled to make preparations against its coming, and summer population at coast resorts that might have been swept away were advantaged by the warning in having been given opportunity to get to places of safety. Cattle on islands that were threatened with submergence were taken to the mainland, and all the section through which the storm was expected to pass was placed in condition of defense against its coming. The Weather Bureau is a great institution and scarcely a week passes that it does not demonstrate its value to the country.—*Charlotte (N. C.) Observer*, September 23, 1920.

A published record of the storms and noteworthy features of the weather of the year appears regularly in the Monthly Weather Review, and little mention of these need be made here.

A storm of extraordinary violence was experienced along the north Pacific coast during the afternoon and evening of January 29, when a maximum wind velocity of 110 miles from the southwest occurred at Tatoosh Island and an estimated velocity of 150 miles from the southeast at North Head was reported. The North Head station anemometer was destroyed by a falling wireless tower when it was recording 132 miles an hour. A maximum velocity of 150 miles an hour is estimated to have occurred.

The winter of 1920-21 was an unusually mild one and no extremely low temperatures were experienced anywhere. The mild weather of March caused vegetation and fruit trees to advance far beyond normal. As a consequence the cold wave of March 27-29, which was the only cold experienced during the month, succeeding the abnormal warm weather, was destructive of fruit blooms over a very large section of the country east of the Rocky Mountains.

The cold weather of March 27-29 was followed by another frost wave early in April, which completed the destruction of fruit blooms in many sections that had escaped the previous freeze. The completeness of destruction of fruit and the wide area affected was the greatest that has been experienced in many years. Accurate warnings were issued in both cases, but the severity of the frost and the impossibility of applying protective measures made it impracticable to avoid the damage.

Special service was rendered on a number of notable occasions. Among them were:

The national balloon race and the international balloon race, which started from Birmingham, Ala., on September 25, 1920, and Octo-

ber 23, 1920, respectively; and the elimination balloon race from Birmingham, Ala., on May 21, 1921, to determine United States entries for the international balloon race to be held in Brussels in September, 1921. Special forecasts were made and weather reports and advices furnished the contestants in these races. In addition, representatives of the Weather Bureau were assigned to Birmingham, special maps were prepared and detailed information supplied to the balloonists. The elimination balloon race was won by Mr. Ralph Upson. Mr. C. G. Andrus, a meteorologist of the Weather Bureau, was Mr. Upson's aid. It is generally conceded that Mr. Andrus's expert knowledge of meteorological conditions was an important factor in winning the race;

The transcontinental record aeroplane flights by Lieut. W. D. Coney, U. S. Army, in February and March, 1921, and trans-continental aerial mail race in February, 1921;

The international yacht races off Sandy Hook, July 15 to 27, 1920.

The United States Army pathfinder aeroplane flights from New York to Nome, Alaska, during the fall of 1920;

Many special forecasts were made at the request of managers of State fairs, local celebrations, and the like. This form of service is rapidly increasing in popular favor.

Special advices and forecasts were furnished in connection with numerous pigeon races during the year. Nearly all carrier pigeon racing associations now depend largely upon the Weather Bureau and do not release the birds until advised by the forecasters that conditions of wind and weather are favorable for flights.

Special forecasts for national election day, November 2, 1920, were issued. This forecast was made on Monday, the 1st, and given distribution through the press associations and also telegraphed to the chairmen of the national campaign committees and to the presidential candidates. The forecasts in this particular case were accurate in practically every detail.

Special forecasts of wind and weather were prepared and radiographed each day for several weeks in October and November for the guidance of the United States submarine naval vessels *Beaver* and *Mallard*, which were engaged in salvaging the United States submarine *S-5* off Delaware Breakwater.

FLYING-WEATHER FORECASTS.

The flying-weather forecasts which were begun in July, 1919, were continued during the year. These forecasts were inaugurated for the special benefit of the air service of the Army, Navy, and Post Office Departments. Their great value to aviation is fully recognized, and during this year a number of organizations interested in commercial flying have been added to the list of recipients of these forecasts. The demands for these forecasts are increasing. This is especially true of individual flyers, who, in addition to the regular flying-weather forecasts issued each morning and evening, desire personal information and advices before beginning flights. For the most part the supplemental information is supplied by telephone. Many daily calls of this character are received. Flyers are coming more and more into contact with the Weather Bureau before beginning flights, an indication of the reliance being placed on weather

forecasts and their indispensability to safe and successful flying. However, the forecasters are handicapped because the number of upper-air and local reports available to them is far insufficient. Reports are needed from more upper-air stations and from surface points at close intervals in every flying zone. By this means far more definite and exact information can be given to aviators.

FIRE-WEATHER FORECASTS.

Fire-weather forecasts were issued during the year and sent to fire wardens and forestry associations in the large forested areas of the country. These forecasts are issued whenever conditions favorable for the inception of forest fires are indicated, and of the approach of rains which may affect their control after fires have started. A protracted dry spell occurred in the Northwest in the summer and fall. Forecasts issued on this occasion, especially in Montana and Minnesota, where the conditions were worse, were of incalculable value in the protection of the forest areas. There is much need for an extension of this work, and forestry and fire-fighting associations have repeatedly petitioned that this service be intensified and extended. A number of stations should be established in the great forest areas for the purpose of collecting more definite meteorological information and studying the whole problem with relation to topography as it affects local wind directions and force. Exceedingly valuable service which would aid in the saving of millions of feet of lumber destroyed each year by forest fires is feasible and practicable if a few thousand dollars were made available therefor. All that it is possible to do with available funds is being done.

RESUMPTION OF WEATHER MAPS.

It was not possible to resume the issuance of maps at stations where they were discontinued during the war, nor will it be practicable to do so until funds are provided for the purpose. Business men, educators, and a larger part of the general public, through many years of usage, understand the weather maps and obtain from them results that bulletins do not supply. Thousands of applications for maps are received. A comparatively small amount of money would enable the Weather Bureau to again place this service on a basis wherein the public and business needs of the country can be met.

VESSEL-WEATHER SERVICE.

Although the war crippled the vessel-weather service to a considerable extent it was gradually restored and this year it has been placed on a higher plane of efficiency than ever before. There are now nearly 100 vessels that radiograph weather conditions at least once daily when they are in certain ocean areas from which observations are desired. With the exception of reports radiographed during the entire year from ships in the Pacific, observations are now confined to vessels plying the South Atlantic Ocean, the Caribbean Sea, and the Gulf of Mexico during the hurricane season, June to November, inclusive. These reports are invaluable in the forecasting of storms and hurricanes.

During the year cooperative arrangements were perfected with the Shipping Board whereby all ships of that fleet when within prescribed ocean zones radiograph daily weather observations to designated forecast centers. This service was begun June 1, 1921.

Cooperative arrangements were also made with the Texas Co., the Standard Oil Co., and the Gulf Refining Co. for ships in those fleets to take and radiograph reports to Washington. This cooperation is highly appreciated, as these vessels navigate largely in the Gulf of Mexico, from which regions observations are especially valuable in connection with hurricane work.

HIGHWAY-WEATHER SERVICE.

The highway-weather service has been continued on the same basis as last year. This service is of established popularity and value, and applications have been received from all parts of the country for its extension. Traffic on highways is so large and is growing so rapidly that it is important that an efficient and comprehensive system of advices concerning road conditions as affected by past and future weather be maintained. The Weather Bureau is well fitted to render this service and has the organization whereby it can be accomplished at a minimum cost. Moreover, automobile associations, road commissioners, and the users of the highways look to the Weather Bureau for the service. The work now done is confined to main highways and in a comparatively few sections. Extensions can not be made until appropriations are made available by which the public demands may be met.

RADIOGRAPHIC DISTRIBUTION OF FORECASTS AND WEATHER INFORMATION.

Radio telegraph and telephony have reached a stage where they must be recognized as potential mediums for the dissemination of weather forecasts, warnings, and information. For some years this has been utilized to some extent, especially in the dissemination of forecasts and storm warnings to ships at sea. A marked extension of the work was made during this year. Since 1914 abbreviated bulletins have been broadcast from the naval radio stations. On November 1, 1920, comprehensive bulletins began to be issued each night at certain scheduled hours from Arlington, Va.; Great Lakes, Ill.; Key West, Fla.; Point Isabel, Tex.; and San Juan, P. R. The bulletins are divided into two parts. The first part consists of reports of barometric pressure, wind direction and velocity and state of weather, taken at 8 p. m. at a number of stations. The second part consists of wind and weather forecasts, storm and hurricane warnings, and advices to shipping.

On June 1, 1921, an extensive morning bulletin began to be broadcast from Arlington containing surface observation (8 a. m.) taken at 42 regular Weather Bureau stations and nine aerological stations maintained by the Navy, Army, and Weather Bureau, a summary of weather conditions over the United States, forecasts and storm and hurricane warnings. This bulletin is for the benefit of marine and aviation interests, but is designed especially to meet the needs of the latter. It is the first wireless weather bulletin for the benefit of aviators ever issued in the United States. A special feature is sepa-

rate flying weather forecasts for six zones covering the entire country east of the Mississippi River. The bulletin is broadcast on high-power wave-length and has a range of about 1,000 miles.

Another bulletin was begun on June 10, 1921, having for its purpose a systematic broadcasting of local weather observations, wind and weather forecasts, storm and hurricane warnings, and advices relating thereto from 26 naval radio stations on the Atlantic and Gulf coasts, in the Caribbean Sea, and on the Great Lakes. This distribution is in the nature of a localized service and supplemental to the general bulletins heretofore referred to.

All of the foregoing bulletins are broadcast from naval radio stations in cooperation with the Office of Communications of the Navy Department.

The use of radiotelegraphy for the benefit of marine interests is well systematized and quite complete, but such is not the case so far as land interests are concerned. However, plans are under way to systematize radio distribution of forecasts and warnings for the special benefit of agricultural and commercial interests and to extend it to every State and section. Forecasts and warnings are now broadcast from a number of colleges and private organizations and from radio stations at Washington, D. C.; Bellefonte, Pa.; Cincinnati, Ohio; St. Louis, Mo.; Omaha and North Platte, Nebr.; Cheyenne, Wyo.; and Reno, Nev., which are operated by the Post Office Department in connection with its transcontinental air-mail service.

The ultimate plan in mind will provide for the distribution on fixed schedules of weather forecasts and warnings from at least one radio station in each State. Existing Government radio stations will be utilized as far as practicable, but cooperative arrangements with commercial companies licensed to engage in radio communications service will also be made in States where Government agencies are not available.

ORCHARD SPRAYING AND HARVEST-WEATHER FORECASTS.

For two seasons special forecasts in connection with orchard spraying activities have been made for the orchardists in northern New York. It has been demonstrated that sprays must be applied to fruit trees just before a rainy spell in order to produce the best results. It requires from 48 to 72 hours to apply the spray in many of the large orchards. Therefore, forecasts for a longer period than is covered by the regular daily forecasts and with the occurrence of rains especially in mind are necessary for this work. Forecasts covering from three to four days were made and with a marked success. The work was so highly commended that there has been a demand for similar service elsewhere. This year a similar service was inaugurated in a limited way for the benefit of orchardists in the region about Gettysburg, Pa.

There has been demand for special weather forecasts having for their direct purpose aid to farmers in the harvesting of hay, oats, wheat, and other crops liable to danger if unfavorable weather occurs between the time of cutting and shocking. Insufficient funds have prevented extensive work of this character, but such service was begun in a limited and experimental way in the early summer

of 1921 in 10 counties in New York. These forecasts are made daily and not for a fixed period as is the case with the general daily forecasts, but for just as long a period as the forecaster feels that the condition as shown on the current weather maps justifies a reasonable expectation of accuracy. Sometimes this period is for 24 hours and at other times three or four days. Moreover, the predictions are worded to apply to the particular purpose and to convey to the farmer the degree of confidence that the forecaster has in the forecast. For instance: "Conditions excellent for drying weather Wednesday and Thursday; Friday uncertain"; or "Outlook for harvesting next two days uncertain; rain very likely." This is information of great value to the farmer, because in effect it is advice and enables him to proceed with his work with either confidence or caution.

The harvest-weather forecast work is conducted in cooperation with the county agents, who have undertaken to disseminate the forecasts by telephone to individual farmers. A full season of this work has not been completed, but an indication of the interest taken in the service is gained by the fact that in one week the county agents in eight counties reported a total of 483 calls from individual farmers for the forecasts.

RIVER AND FLOOD SERVICE.

As in other lines of effort, high charges and stationary appropriations precluded improvement or extension of the river and flood service. Equipment has been repaired or renewed only where absolutely necessary, less urgent cases being deferred to some more opportune future time. The extensions that should go hand in hand with the increasing development of the business of the country, and especially of the development of water supply for hydroelectric, irrigation, and other purposes, must also be deferred, and the demands for them still exist and are increasing. At present the greatest demand is for a large increase in the number of precipitation stations and a plan of campaign is in progress of development to meet the situation.

Another legitimate field of expansion lies in the operation of river stations throughout the year. At present many are operated only during the flood season, which is sufficient for flood purposes, but engineering interests engaged in problems involving water run-off and supply constantly need data regarding low as well as high water, and these the Weather Bureau should be in a position to furnish.

The flood-warning service has met all demands upon its present organization, and the only extensions needed apply to some of the smaller rivers not now enjoying the benefits of flood-warning service. Repairs to much of the equipment and more thorough standardization and coordination are really necessary, but under existing conditions they must wait.

While floods were fairly numerous during the year, especially in the South Atlantic and East Gulf drainage basins, they were in the main of moderate character. The outstanding exceptions were the great floods of June in the Arkansas and lower Colorado Rivers. The Arkansas River flood was caused by torrential downpours of

rain over comparatively limited mountain areas in eastern Colorado, and was especially destructive at and in the vicinity of Pueblo, Colo. Here the crest stage of the flood was more than 12 feet above the highest stage of previous record—120 lives were lost and 143 persons were unaccounted for, while the property losses amounted to at least \$25,000,000. The Colorado River flood was due to a combination of heavy rains and melting mountain snows, and at some places the highest stages of record were reached.

Mountain snowfall measurements were continued in the West. Here, again, the water-supply interests are demanding increased service. The necessity therefor is admitted and it can be accomplished only by more intensive snow surveys and an extension of the work into the highest mountain regions. The importance of this work to the irrigation and hydroelectric interests is apparent, a preliminary campaign along new lines has been outlined, and a moderate estimate of funds necessary therefor has been submitted.

The Wagon Wheel Gap Experiment Station maintained in connection with the Forest Service of the department has been continued during the year, and a discussion of the results of meteorological and stream-flow observation has been completed and sent to the printer. According to present plans the whole project will be completed within two or three years, and the final results announced within a reasonable time thereafter.

STATIONS AND ACCOUNTS DIVISION.

WEATHER BUREAU QUARTERS IN FEDERAL BUILDINGS.

Removals of local offices to Federal buildings were made during the year wherever quarters therein suited to Weather Bureau work were obtainable. Such removals were made at Corpus Christi, Tex., and Moorhead, Minn.

RENTED QUARTERS FOR WEATHER BUREAU OFFICES.

There were in all 20 stations where existing leases for rented quarters expired by limitation June 30, 1921. The unusual increase demanded generally for these quarters, averaging more than 33 per cent, necessitated drastic action to keep within the limits of the appropriation, and the matter was then taken up in detail, considering the activities of each station with relation to space occupied. In addition, there were considered also seven stations at which leases expired subsequent to June 30, 1921. To have met the proposals of the various landlords in these cases would have imposed an increased expenditure for rents amounting to \$8,446.60. This amount was wholly unavailable, and the exigency has been met by the release of a total of 5,112 square feet of floor space, much of which is in reality essential to the proper conduct of the activities at many of the stations involved.

A frame-cottage building rented and utilized for Weather Bureau quarters on Mount Tamalpais, Calif., since the establishment of that station, September 2, 1898, being no longer suitable for the purpose, the station at that place was discontinued May 16, 1921.

The status of Weather Bureau offices on June 30, 1921, at stations outside of Washington is as follows:

Free quarters and accommodations:	
Observatory buildings (owned and controlled by the Weather Bureau)	45
State university buildings	5
Federal buildings	76
Total free of rental	126
Rented buildings, etc., owned by individuals or corporations:	
Office buildings	88
Buildings with grounds, aerological stations	6
Total number rented buildings partly or wholly occupied	94
Total	220

TELEGRAPH DIVISION.

Telegraphic communication by the utilization of commercial services, as heretofore, was maintained at practically all of the field stations in a generally satisfactory manner, except at some corn and wheat and cotton centers. Delays in the early collection and prompt distribution of daily weather and crop reports occurred in certain localities because of the late opening of the telegraph offices. This difficulty could be overcome by resort to use of the telephone or by employment of special operators were funds available.

Telegraphic work at the central office was accomplished during the first half of the year with much difficulty, due to the loss of trained and capable employees by resignation and retirement. Auditing of telegraph, telephone, cable, and wireless accounts and recording became badly delayed in the autumn, but with the assistance of an efficient temporary employee, together with assiduous labor by the older members of the division, this important part of our work was brought up to date in May.

Delay in receipt of cablegrams and wireless reports from ships at sea, especially those in and contiguous to the Caribbean Sea, continued generally throughout the six months' hurricane season, notwithstanding repair of several cables previously reported as broken. Congestion at cable points and unfavorable atmospheric conditions due to static electricity are given as the chief causes of the slow service.

Prompt and efficient telegraph and telephone service is intimately connected with and necessary to reliable forecast work. The gradually increasing volume of telegraphic business resulting from natural expansion of the forecast service at the central office has imposed a corresponding strain upon this division with its number of employees stationary for some years past. Arrangements are now in progress, however, for supplying the need for permanent additional help.

Contracts with the various wireless telegraph companies and also with the numerous telephone companies, with the exception of one operating in Oklahoma, were renewed for the fiscal year 1922 on favorable terms.

The nature and status of the several Weather Bureau telegraph and telephone lines have been more or less fully set forth in the

two or more preceding annual reports, and detailed comments may be omitted here.

The most severe damages and interruptions to service occurred on the line between Tatoosh Island and Port Crescent, Wash., attending the very destructive storm of June 29, 1921. This line is of great value to logging, shipping, fishing, and other commercial interests. Vessel reporting is conducted at Tatoosh, Neah Bay, Clallam Bay, and Port Angeles, and data telegraphed from the latter station to interested parties. The Neah Bay office has been equipped with a radiotelephone set furnished and installed by the Navy Department for use in emergencies to transfer distress warnings to the Coast Guard station at that point. It has been used also to good advantage in transacting business with Tatoosh Island when wire communication was interrupted.

About 10,000 commercial messages were handled during the year, about 3,000 Government messages were transmitted, and about 1,500 long-distance telephone calls.

While all these lines are maintained primarily to carry important Weather Bureau reports and warnings where no commercial lines are available for the service, nevertheless the Government derives a significant amount of income from local commercial messages carried for the public at very small charges, 15 cents, etc. The following table indicates the receipts for the year:

Month.	Block Island.	Cape Henry.	Beaver Island.	North and South Manitous.	Port Angeles.
1920.					
June.....	\$50.75	\$207.38	\$26.70	\$14.69	\$212.86
July.....	178.42	197.46	38.12	14.85	210.18
August.....	324.53	206.11	66.14	15.10	235.70
September.....	90.84	209.30	56.08	11.83	169.58
October.....	19.92	224.47	42.07	5.57	168.05
November.....	9.45	242.62	52.82	4.25	111.97
December.....	10.37	286.96	46.12	2.90	230.39
1921.					
January.....	7.55	255.25	35.85	1.10	\$2.49
February.....	4.32	139.58	22.78	2.68	81.47
March.....	5.92	205.28	23.00	3.22	103.90
April.....	14.36	154.60	45.17	13.15	141.44
May.....	22.94	145.24	34.72	6.78	144.81
June.....	39.19	1,200.00	41.37	16.57	199.00
Total.....	778.76	2,675.25	530.94	112.69	2,095.75

¹ Estimated.

Grand total, \$6,193.39.

AEROLOGICAL INVESTIGATIONS.

Free-air observations by means of kites and balloons were continued throughout the year. This work has become an important integral part of the Weather Bureau's program, and should be developed and expanded as rapidly as possible, in order that the United States may keep pace with the rest of the world in the investigation of the phenomena of the free atmosphere now so much needed for the advancement of the art of general weather and storm forecasting and for the benefit of aeronautics.

KITE STATIONS.

Observations with kites were made regularly at Broken Arrow, Okla.; Drexel, Nebr.; Ellendale, N. Dak.; Grosbeck, Tex.; and Royal Center, Ind. The station at Leesburg, Ga., was transferred to Due West, S. C., and observations were begun at that station in March, 1921. Kite flights are made daily, whenever possible, and in addition, when conditions are favorable, a continuous series of flights are made for periods of 24 to 36 hours. Records of air pressure, temperature, humidity, and wind are thus obtained. Brief summaries are telegraphed daily to the central office and other district forecast centers.

PILOT-BALLOON STATIONS.

Observations by means of pilot balloons were continued at five of the kite stations (all except Drexel, Nebr.) and at Burlington, Vt.; Denver, Colo.; Ithaca, N. Y.; Key West, Fla.; Lansing, Mich.; Madison, Wis.; San Juan, P. R.; and Washington, D. C. During the latter part of the year this work was begun also at San Francisco, Calif. The observations are made twice daily for the most part, and the computed wind conditions at various heights are telegraphed to the central office, where they form the basis for "Flying Weather" forecasts issued to the military, naval, and postal aviation services.

Special observations have been made from time to time in connection with transcontinental airplane flights and the national and international free balloon races at Birmingham, Ala.

COOPERATION.

Effective cooperation with the Army and Navy meteorological services has been continued throughout the year. Each of these services maintains a number of pilot-balloon stations, whose primary purpose is to furnish data of immediate local interest to aviators at flying fields. These observations are also telegraphed to the central office of the Weather Bureau for use in issuing "Flying Weather" forecasts. They thus supplement in a very helpful way the surface and free-air observations made at Weather Bureau stations. In addition to the stations in the United States proper, the Navy maintains one at Santo Domingo, Dominican Republic, and one at Coco Solo, Canal Zone, which, together with those of the Weather Bureau at San Juan, P. R., and Key West, Fla., furnish information of value in connection with the development and movement of hurricanes. A much larger number of stations is necessary, however, to make this service as effective as it should be.

In order to check the accuracy of the formula used in determining the rate of ascent of pilot balloons, the Weather Bureau and the Army meteorological service each made a large number of double theodolite observations. These formed the basis for a study which resulted in a slight modification of the formula and in the introduction of a small additive correction during the first few minutes of ascent. It is believed that the revised formula gives extremely reliable results, except when there are pronounced vertical movements in the atmosphere. Even then the error is appreciable only in the lower layers.

CENTRAL OFFICE.

All observations made at kite and balloon stations, by the Army and Navy as well as by the Weather Bureau, are forwarded to the central office of the Weather Bureau for final reduction and study. Data based upon these observations are furnished in answer to numerous inquiries not only from other Government departments, but from commercial aviation concerns as well. In many cases reprints of special discussions and summaries were issued in answer to these requests. A more complete summary than has heretofore appeared is now in preparation and will soon be published. This will be based upon all free-air observations thus far obtained in this country and is designed to meet particularly the needs of aviators and those interested in the development of commercial aviation on a large scale. A manual entitled "Instructions for Aerological Observers" was prepared and published. This gives in detail all the steps necessary (and the reasons therefor) in making and reducing observations by means of kites and pilot balloons; also, a description of all instrumental and other equipment used. It fills a long-felt want and will be of special value in the event that a proper expansion of aerological investigations is made possible.

CLIMATOLOGICAL WORK.

The examination and checking of station meteorological reports of all classes showed some improvement in the general character of the work performed by both the regular and cooperating observing force, due doubtless to the more stable conditions affecting the personnel than had prevailed during several preceding years.

COOPERATIVE WORK.

Only words of highest appreciation and commendation should be applied to cooperating observers for the loyal and faithful service they have rendered the Government and people everywhere as a result of their painstaking labors in maintaining continuity of observations over a period of trying times and furnishing data necessary to meet the requirements for climatic information during the past few years.

At a time when personal service was highly valued and people everywhere were clamoring for increased compensation, these observers continued their work without any monetary compensation or thought of personal gain.

In the main reports from these observers have been rendered continuously and promptly, and a rigid examination of their reports discloses that scrupulous efforts are made to correctly interpret the indications of the instruments and otherwise to record the exact weather conditions.

ESTABLISHMENT OF NEW STATIONS.

Despite many offers of cooperation and requests for the loan of instruments for making weather observations, the number of full cooperative stations has been but slightly augmented during the year, partly from the necessity of economy and partly as a result of

a general belief that the number of temperature-reporting stations is now sufficient for practically all needs.

More consideration has been given the establishment of rainfall-reporting stations, however, as it is generally felt that the number of these reports might be considerably increased. Limited funds for the purchase of gages has likewise discouraged the opening of such stations, except at the most desirable points.

INSPECTION OF COOPERATIVE STATIONS.

The program providing for the regular inspection of cooperative stations once in each three years was greatly abridged during the year just closed, due to the increased cost of travel and the frequent inability of station officials, on account of inadequate assistance, to absent themselves from their regular station duties.

It is felt that the best interests of the Bureau and the country at large are greatly conserved by reasonably frequent visits to these cooperative observers by those responsible for the development of this line of the Bureau's work. Contact with these observers by the proper representatives stimulates the cooperative spirit, affords chance for righting faulty exposures of instruments, correcting erroneous methods of handling them, and recording their indications.

MATERIAL FOR PUBLICATION.

The text, tables, and charts prepared for use in the regular publications of the Bureau, particularly the Annual Report, the Monthly Weather Review, and the Snow and Ice Bulletins, were available for the printer at the proper time, and those published directly under the supervision of this division were issued promptly.

Material for the reprint of a number of the exhausted parts of Bulletin W were prepared during the latter part of the year. Several have already been issued, and about 10 more are now at the Government Printing Office awaiting opportunity to print.

The monthly and annual section reports printed at the respective State centers were issued in the main at the prescribed times. Lack of efficient printing help at some of the stations delayed the issuance accordingly, and the prompt assembling and binding of the complete sets for all States has been prevented by the late receipt of a few of the sections.

The section annuals for 1920 were available for issue from most of the sections at the usual time, but the delay in issuing the monthly numbers at a few stations was also carried forward to the annuals and at the close of the last fiscal year one or more sections had not yet completed the annuals.

The sets of these monthly and annuals 1919, for station use, about 140 sets, were assembled, bound at the Government Printing Office, and the complete sets mailed from this division as usual.

CHANGES IN PUBLICATIONS.

On account of the high cost of paper and the general need for economy, the Annual Climatological Summaries, 1920, were materially reduced in size, and, beginning with the January, 1921, num-

ber, the monthly summaries have been issued without the usual cover and in some cases still further reduced in size. Great care was exercised to retain all the valuable features possible, and as no material complaints have arisen it is assumed that though reduced in size the material furnished meets the more pressing needs of the public.

BINDING AND PRESERVATION OF METEOROLOGICAL RECORDS.

The assembling and binding of the original meteorological records for the regular stations went forward as usual and the work of assembling several years of the cooperative observers' records and their preparation for binding is also nearing completion.

NEW WORK.

The revision of the parts of Bulletein W, bringing the various tables and other matters down to the end of 1920, is now being carried forward and it is hoped the reprinting of these can be accomplished during the year.

As the first edition of these separates was issued more than 10 years ago, the supply of a number of the important parts has become exhausted and much additional labor in preparing answers to public inquirers can be saved by having them all reprinted. Effort is being made to include much additional material not carried in the earlier issues, necessitated by the constant public demand for more details of the weather and climate over the different parts of the country.

The preparation of new daily, weekly, and monthly normals of temperature, delayed for a considerable period from unavoidable causes, is now being taken up, and it is hoped they may be completed and put in use during the present year.

OCEAN METEOROLOGY.

In consequence of the operation of the retirement act it was necessary, near the beginning of the year, to reduce the force engaged upon the work of ocean meteorology at the central office. This action in turn resulted in the suspension of work upon certain projects. In general, however, the purely routine work has been carried on as usual.

At Weather Bureau stations in the principal ports, where marine work is carried on, generally less contact with the marine observers has been maintained on account of increased demands on the station force for service which could not be deferred.

The work of ocean meteorology, as conducted by the United States, rests upon the voluntary efforts of masters and officers of the world's merchant marine. Experience has shown that a certain measure of personal contact is necessary to insure keeping this cooperation up to the desired volume and standard and that when this contact breaks down the work suffers accordingly.

The revival of United States shipping and the cordial cooperation with the Weather Bureau on the part of the Shipping Board has for the moment offset the enforced inactivity on the part of the Bu-

reau. The situation can not continue, however, without serious detriment to the work.

The foremost maritime nations have always fostered the work of ocean meteorology as conducted by their several Governments, and it is the belief of officials of the Weather Bureau that the United States in the development of its own merchant marine must follow the examples set by these nations.

Recommendations for the support and extension of this work, believed to be in keeping with the general policy of economy, have been made in the estimates for the ensuing fiscal year.

AGRICULTURAL METEOROLOGY.

Collection of meteorological data for each week ending Tuesday at 8 a. m. and the effect on vegetation, stock, and farm work, and the publication of these facts in the National Weather and Crop Bulletin on Wednesdays at 11 a. m. has been continued throughout the year. This bulletin has been reduced from eight to four pages during most of the time to conserve time and supplies; during the winter months it was combined with the Snow and Ice Bulletin. Throughout the growing season a special corn and wheat region bulletin has been published at New Orleans covering the cotton belt; local summaries covering individual States have also been issued from each section center. These reports are very popular, as they give in condensed form the only available rainfall and temperature data covering the whole United States.

SPECIAL SERVICES.

Publication of daily bulletins giving in tabular form rainfall and temperature during the preceding 24 hours was continued in the principal corn, wheat, cotton, sugar, and rice States. The opening of this service was delayed from April 1 to May 1 in 1921 in the interest of economy in salaries to special observers, telegraph service, and supplies. The weekly collection of meteorological data and its publication in bulletin form were continued in the range districts in Texas, New Mexico, Arizona, Utah, and Wyoming. There has been a strong demand for the extension of this service in other cattle-grazing States, particularly Montana.

The collection of temperature data from special stations in the tobacco, fruit, truck, and alfalfa-seed districts to aid in issuing warnings of damaging temperature was continued during the critical frost season. An imperative reduction in the office force at Hartford, Conn., made it necessary, however, to permanently discontinue this service in the Connecticut Valley tobacco district during the spring of 1921. Lack of funds prevented the detail of a field official to continue special temperature studies in the Pomona, Calif., citrus region during the winter of 1920-21, but the work was continued in the Rogue River Valley in Oregon, where it was of especial value in the deciduous fruit orchards. Special weather warning services for spraying operations were continued in New York and Michigan, and this service was inaugurated in a limited way at Wytheville, Va.

INVESTIGATIONS.

Mathematical studies of the effect of weather on crops have been carried on as opportunity permitted. Papers published on these studies are:

KINCER, J. B. Computing the Cotton Crop from the Weather and Ginning Reports, *Monthly Weather Review*, May, 1921.

YOUNG, F. D. Influence of Exposure on Temperature Observations, *Monthly Weather Review*.

— Rate of Increase in Temperature with Altitude during Nights in Orange Groves in Southern California, the *California Citrograph*, March, 1920.

— Effect of Topography on Temperature Distribution in Southern California, the *California Citrograph*, May, 1920.

— Smoke and Direct Radiation in Frost Protection, *Better Fruit*, December, 1920.

KIMBALL, H. H. Smudging as a Protection from Frost, *Monthly Weather Review*, August, 1920.

Investigations in hand relate particularly to the effect of weather on corn over comparatively small areas in Ohio, Nebraska, and Illinois, and on cotton in South Carolina, Arkansas, and Texas. The further these investigations are carried the more important it seems to establish a number of agricultural meteorological stations at well-distributed experiment stations.

PRINTING.

The utmost economy was practiced in the issue of publications and the purchase of necessary supplies of paper, tagboard, ink, and other printing materials. No new equipment of consequence was installed throughout the year.

The revision of our mailing lists admitted of dropping 90 addresses from the *Daily Weather Map*, 654 from the *National Weather and Crop and Snow and Ice Bulletin*, 50 from the *Climatological Data of the United States by Sections*, and 128 from the *Monthly Weather Review*.

Paid subscriptions for the *Monthly Weather Review* are filled by the superintendent of documents, Government Printing Office, from the 250 copies furnished him each month by the printing division.

Special arrangements were made with the superintendent of documents in March, 1921, whereby the superintendent agreed to pay the Bureau for 250 copies of the *Monthly Weather Review*, which for years have been furnished to him free of charge.

THE MONTHLY WEATHER REVIEW.

The *Monthly Weather Review*, exclusive of charts, has contained an average of 63 pages of text and tables in each of the 12 issues which have appeared during the fiscal year.

The publication has been and continues to be practically the only medium in the United States for the diffusion of knowledge respecting meteorology, not only as to current and average weather conditions, but also as to any progress which may have been made in advancing the science at home or abroad. It also, in no less degree, aids in the eradication of false ideas, which everywhere abound respecting the weather. At the same time it aims to stimulate and assist in giving wholesome instruction in meteorology in secondary schools, colleges, and universities.

INVESTIGATIONS IN SEISMOLOGY.

The important work of collecting and publishing earthquake data, begun December 1, 1914, has been continued during the year.

During the calendar year 1920, 106 separate earthquakes strong enough to be felt by the senses were reported from different parts of the continental United States. The great majority of these produced little or no damage, but an earthquake of considerable intensity occurred in the vicinity of Los Angeles on June 22, followed by milder shocks in July, both accompanied by somewhat extensive damage.

The conduct of the work in volcanological observation at the Hawaiian Volcano Observatory, in the Hawaiian Islands, was assigned to the Bureau by legislative action in the appropriation bill for 1919. The standard program of observations has been carried out, as heretofore, under the direction of Dr. James A. Jaggar, jr., who inaugurated the work, and who is assisted by a small staff of specialists. The results of the observations are published from month to month in a small bulletin printed at Honolulu, and supplemented by occasional notices in the newspapers, as circumstances justify.

LIBRARY.

During the fiscal year 850 books and pamphlets were added to the library, the strength of which is now over 40,000. Routine work has been kept fairly well up to date, in spite of a reduced staff, but no important special undertakings are possible without a much larger trained personnel. In proportion to its size and varied program the Weather Bureau library has probably a smaller staff than any other Government scientific library, and there are cases in which much smaller libraries have staffs at least 10 times as great.

The exhaustive bibliography of the climatology of South America, begun two years ago, is in the hands of the printer, and it is hoped will soon be ready for distribution.

SUPPLIES.

The purchase of all property and supplies for the Weather Bureau are made by the Supplies Division, and it is responsible for all property in the central office. It is charged with the supervision of all property issued to the stations of the service in various parts of the United States and the West Indies. This division is also charged with the distribution of property and supplies to and from stations. These shipments are made direct under Weather Bureau bills of lading, as a rule, and through the United States dispatch agent at New York and the Quartermaster Department. During the fiscal year 1921 all shipments have been promptly made and carried through to destination without unnecessary delay.

During the fiscal year just ended, the various duties of this division have been fulfilled and the equipment of the central office and the several stations fully maintained. All property and supplies have been purchased and delivered according to law.

The annual property returns from stations were all duly received in this division, examined, discrepancies adjusted, and the papers filed.

All reports relative to property called for, such as motor-propelled vehicles, typewriters, etc., have been promptly made. All worn-out and unserviceable property has been disposed of according to law and the regulations of the department.

INSTRUMENT DIVISION.

STATION EQUIPMENT.

The activities of the Instrument Division during the year that ended June 30, 1921, have been devoted largely to the maintenance of regular, special, and cooperative station equipment with a stationary allotment of funds at a time when prices are high. The general policy of the Bureau has been to discourage extensions of the service. This policy has made it possible to get along with existing instruments, repaired in our own machine shop as they become unserviceable.

STORM-WARNING EQUIPMENT.

Largely as a result of the thorough overhauling and standardizing of the storm-warning display equipment in previous years, the expense of maintaining the towers has been small. The new sherardized conduit has begun to rust, however, and should soon be painted. It is found to rust far more quickly than the towers to which it is attached.

NEPHOSCOPES.

One hundred nephoscopes have been installed at selected stations of the Bureau. It is hoped that in the near future it may be practicable to formulate and get into practice a regular program for nephoscopic observations of clouds.

NEW INSTRUMENTS.

Improvements have been effected in a type of weighing rain-gage and a self-contained tipping-bucket rain-gage was designed with special reference to the rainfall-insurance problem.

A wind-vane commutator has been designed by Mr. Kadel for use as regular Weather Bureau station equipment. A description of this will appear in the *Monthly Weather Review*.

Three sets of apparatus for testing aneroid barometers have been designed. One of these will be retained as laboratory equipment, and the other two will be sent to New York and New Orleans. A triple register or meteorograph for making records in duplicate has been designed and constructed in the division and is now in successful operation at the New York station.

EVAPORATION.

The following listed evaporation stations are sending monthly reports:

Agricultural College of New Mexico.
Ajo, Ariz.
Arrowrock Reservation, Idaho.
Austin, Tex.
Centerville Lake, Minn.

Chapel Hill, N. C.
Chula Vista, Calif.
Columbia, Mo. (Weather Bureau).
Columbia, Mo. (University).
Columbus, Ohio.

Corvallis, Oreg.	Roosevelt Reservation, Ariz.
Deer Flat Reservation, Idaho.	St. Croix, Virgin Islands.
Dodgeland, Calif.	San Juan, P. R.
Elephant Butte, N. Mex.	Santa Fe, N. Mex.
Hoaeae, Upper, Hawaii.	Sheridan Field, Wyo.
Ithaca, N. Y.	Silverhill, Ala.
Jerome, Idaho.	Sun River Canyon, Mont.
Kachess Lake, Wash.	Tahoe, Calif.
Lincoln, Nebr.	Tribune, Kans.
Maunawili Ranch, Oahu, Hawaii.	Tucumcari, N. Mex.
Mesa, Ariz.	Walla Walla, Wash.
Mud Lake, Idaho.	Willcox, Ariz.
Myton, Utah.	Willow Creek, Mont.
Oakdale, Calif.	Wichita, Kans.
Pahrump, Nev.	Wooster, Ohio.
Piute Dam, Utah.	Yuma (Evap.).
Provo, Utah.	Yuma (Citrus).
Rapid City, S. Dak.	

INVESTIGATIONS IN SOLAR RADIATION.

Six thermopiles, construction of which was commenced in our machine shop in December, 1920, should be completed as soon as possible. These are designed for two purposes: (a) To be exposed horizontally under a glass cover to measure the total solar and sky radiation received on a horizontal surface; (b) to be exposed in a diaphragmed tube on an equatorial mounting, which permits of keeping the tube pointed to the sun, so that the intensity of direct solar radiation may be continuously measured.

In order to obtain continuous records from these thermopiles a register is required, the present price of which is \$460. The purchase of one of these was requested during the year 1921-22, and another should be purchased during the year 1922-23 for use outside of Washington. It is expected that this instrument will practically eliminate the necessity of eye readings of pyrheliometers, thereby saving in one year in labor nearly the equivalent of its cost.

It is hoped that by the use of absorption screens in connection with the apparatus described above it may be possible to obtain continuous records of the luminous intensity of solar and sky radiation. Such records are urgently requested by members of the Illuminating Engineering Society and others. Eye measurements of sky brightness and of the intensity of daylight illumination upon surfaces facing in different directions are now being made in Washington, and measurements at other points, and especially in smoky cities, are contemplated. For this purpose the purchase of a photometric outfit, costing about \$250, has been requested during the fiscal year 1921-22. A similar purchase should be made during the fiscal year 1922-23.

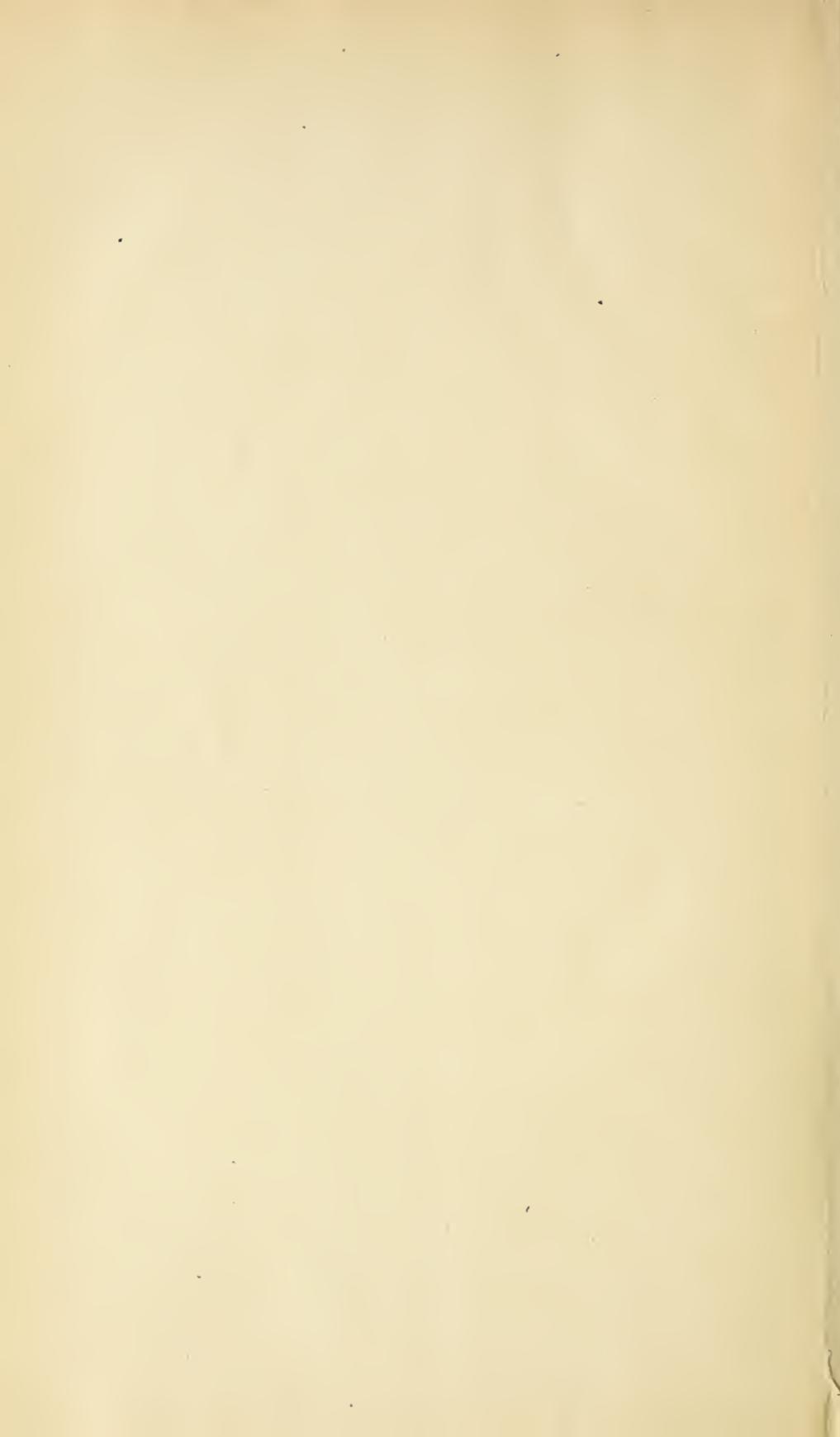
The observations and measurements in solar radiation by the Weather Bureau are confined to intensities at the surface of the earth. Nevertheless, a problem of great importance attaches to the question of possible day-to-day variation of intensity of the radiation of the sun as it reaches the outer limits of the earth's atmosphere. Measurements of this quantity are made only with great difficulty, but for many years the Astrophysical Observatory of the Smithsonian Institution has been making such determinations, and very recently systematic arrangements have been made for the maintenance of

observations, as nearly daily as possible, at two widely different stations, one near Calama, Chile, and another in the southwestern portion of Arizona. Through the cordial cooperation of Dr. Abbot, the director of the observatory, results of these measurements are furnished to the Weather Bureau, which publishes them systematically in the pages of the *Monthly Weather Review*.

Studies of the relation between these day-to-day observations of solar intensity and the phenomena of the weather have been made by a number of different students, with the view to establishing important correlations which permit of successfully forecasting the weather. However, the investigations which have been made by the Weather Bureau tend in the main to discredit the relatively optimistic views of those who advocate that small variations in observed solar intensity are satisfactory indications of coming atmospheric conditions at given localities.

Especially do the investigations of the Weather Bureau indicate that the claim that there is a distinct variation of a few per cent in solar radiation from day to day has little scientific foundation. These variations are more easily explained as errors of observation—that is, errors introduced in the measurements by the known influence of the atmosphere of the earth in absorbing portions of the incoming radiation—leaving the conclusion that if any actual systematic day-to-day fluctuations occur in the intensity of the solar radiation as it reaches the outer limits of the earth's atmosphere, they are very small; that is, of the order of two or three tenths of a per cent.

These views are not to be interpreted as applying to possible slow changes of long periods—weeks, months, years, perhaps—of intensity of solar radiation. This important question calls for many accurate observations of radiation intensities.





12447 OF THE
SERIES OF 100000 STAMPS
DECEMBER 1991
GOVERNMENT STATION NO. 2

